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REFRESHING
S H A R E

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Spencer Weiner/USFWS

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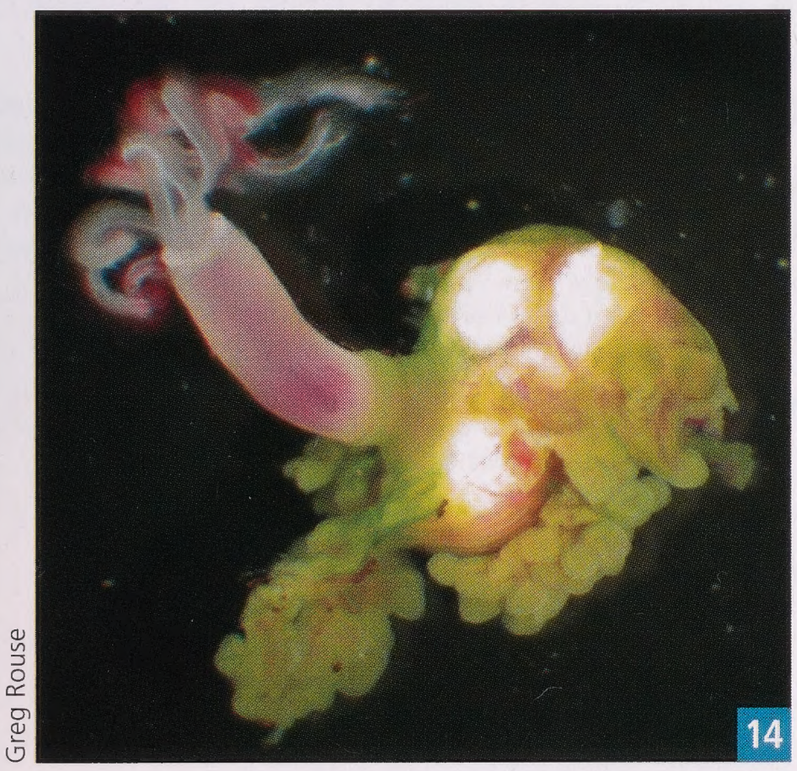
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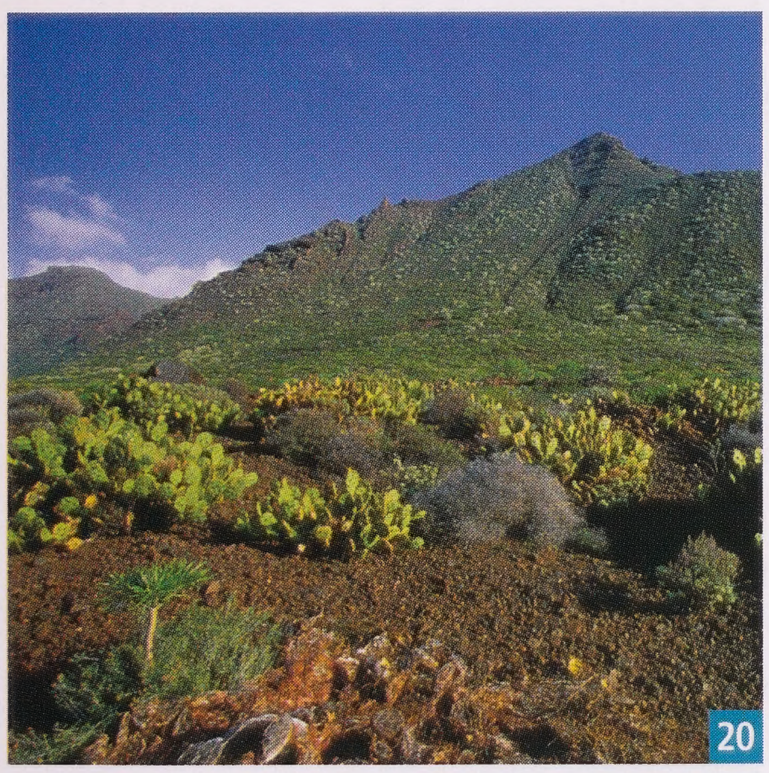
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FONZForum

Saving Asian Species

If you have visited the Zoo lately, you will have seen the amazing progress being made on the construction of Asia Trail. Scheduled to open in 2006, Asia Trail includes an expansion of the Fujifilm Giant Panda Habitat, as well as new homes for sloth bears, fishing cats, clouded leopards, small-clawed otters, and giant salamanders. While construction continues on Asia Trail's physical plant, Zoo scientists are conducting research, in the wild in Asia and on Asian species in zoos, that will be highlighted on Asia Trail.

Many of you are familiar with Zoo scientists' extensive research and conservation program for giant pandas. Working here at the Zoo, in Chinese breeding facilities, and in the wild in China, the scientists are advancing our understanding of behavior and reproduction in giant pandas, pioneering techniques to measure reproductive and stress hormones, improving the health and welfare of giant pandas in Chinese facilities, and monitoring giant pandas and other mammals in several Chinese reserves. They are also helping to build capacity for conservation by providing professional training to Chinese biologists—some 427 individuals since 2001.

Less well known is the depth and breadth of Zoo scientists' work in Thailand, which includes scientific research, consulting, and building capacity for conservation. Among their projects:

- In partnership with the Zoological Park Organization of Thailand (ZPOT) and Thai university veterinarians, they are improving breeding and management programs for several Southeast Asian endangered species including clouded leopards, Eld's deer, fishing cats, and Asian elephants.
- Also in partnership with ZPOT and the Nashville Zoo, which coordinates the project, they are developing genetic management plans and captive breeding programs for clouded leopards and fishing cats in Thailand.
- They are collaborating with the Thailand Department of National Parks, Wildlife and Plant Conservation, Wild Aid (an international conservation organization), and others to conduct habitat surveys and monitor endangered carnivore, deer, and elephant populations in Thai national parks.
- They are training the next generation of Thai conservation scientists, wildlife biologists, zoologists, veterinarians, and policy makers in core conservation biology disciplines.

The conservation impact of these projects is exemplified by the success of the clouded leopard breeding program at Thailand's Khao Kheow Open Zoo. The majority of this zoo's captive clouded leopards are genetically valuable, wild-born animals that have been donated or confiscated from poachers. But they weren't breeding and contributing to the captive population. Clouded leopards generally have a poor breeding record in captivity, in large part because putting a male and female together often results in the male killing the female. But Zoo scientists also found that poor nutrition and stress resulting from their inadequate enclosures were contributing to the clouded leopards' failure to reproduce. With advice and assistance from Zoo staff with experience in the delicate task of pairing males and females, spacious new habitats were created for Khao Kheow's animals and their diets were improved. As a result, 12 clouded leopards have been born, of which ten survived, since May of 2002!

Two cubs, a male and a female, will soon be coming to the United States to be paired with clouded leopards in zoos here, as part of the Species Survival Plan's efforts to bolster genetic diversity. The Thailand female, in fact, is coming to the Zoo's Conservation and Research Center (CRC), where she will be mated with a male coming to CRC from the Point Defiance Zoo in Tacoma, Washington.

FONZ is helping in a variety of ways to fund these programs. In 2003, for instance, FONZ Young Professional (YP) members contributed $10,000 to the clouded leopard project. Recently, FONZ secured a grant of $200,000 from the Freed Foundation to complete interpretative elements and landscaping of the clouded leopard exhibit. If you would like more information or to contribute to these or other conservation programs, please contact our development office at 202.673.4682. The support of FONZ members is crucial to the survival of wild animal species in our human-dominated world. Thank you.

Sincerely,

Tom LaRock
Executive Director

FONZ Friends of the National Zoo is a nonprofit organization dedicated to supporting the conservation, education, and research efforts of the Smithsonian's National Zoo. Formed in 1958, FONZ was one of the first conservation organizations in the nation's capital. Friends of the National Zoo is dedicated to supporting the National Zoo in a joint mission to study, celebrate, and protect the diversity of animals and their habitats.

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Smithsonian **National Zoological Park** is located at 3001 Connecticut Ave., N.W., Washington, D.C., 20008-2537. Weather permitting, the Zoo is open every day except December 25. Hours: From April 3 to October 31, grounds are open from 6 a.m. to 8 p.m.; buildings, 10 a.m. to 6 p.m. From November 1 to April 2, grounds are open from 6 a.m. to 6 p.m.; buildings, 10 a.m. to 4:30 p.m.

Membership in FONZ offers many benefits: programs, publications, discounts on shopping and events, free parking, and invitations to special programs and activities to make zoogoing more enjoyable and educational. To join, write FONZ Membership, National Zoological Park, 3001 Connecticut Ave., N.W., Washington, D.C., 20008-2537, call 202.673.4961, or go to www.fonz.org.

Membership categories and annual tax-deductible dues are:

Family (includes children 3-16 years)	$50
Double	$45
Individual	$40
Senior Citizen Individual	$30
Contributing	$75
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Patron	$250
Sponsor	$500
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($8 of membership dues goes to a *ZooGoer* subscription)

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Cover photo: One of four cheetah cubs born at the Smithsonian's National Zoo in November 2004 explores the outdoors. Photo by Jessie Cohen/NZP.

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The Smithsonian's National Zoo is accredited by the American Zoo and Aquarium Association.

Letter from David L. Evans

Science Matters

During 2004, the Smithsonian Institution completed its first strategic plan for science. Entitled "Science Matters: Priorities and Strategies," this plan encompasses all of the science units of the institution, including the National Zoo.

Ever since the Smithsonian brought endangered bison to the National Mall and later moved them to Rock Creek Park, we have been engaged in the study, celebration, and protection of the other species with which we share the planet. That work continues to be a priority under the theme of Discovering and Understanding Biological Diversity, one of four themes for Smithsonian Science. Priority research includes studies of the biology of extinction, which will seek to understand the extinction of species and loss of habitats, whether past or present, and provides strategies for reversing human impacts and restoring and protecting species and their habitats. To accomplish this, we expect to establish the Smithsonian Center for Conservation Biology, linking facilities and talents across the institution, and expect the Zoo to play a major role. National Zoo and other Smithsonian scientists are also helping to create NEON—the National Ecological Observatory Network. The first-ever national ecological observation system, it is being designed to allow scientists to develop a predictive understanding of the relationship between environmental change and biological processes.

We are also committed to enhancing collections management and accessibility; the storage, conservation, and preservation of natural collections; and the housing and welfare of living collections. We will strengthen the public's appreciation of life's diversity, and completing the new Asia Trail at the Zoo will help us meet that goal.

I am quoting below some of the introductory material from "Science Matters" to share with you the overall framework in which the Zoo plays an integral role.

There Is But One Smithsonian Institution

"Since its founding in 1846, the Smithsonian Institution has played a prominent role in a wide variety of scientific disciplines. Coupled with these efforts is the Smithsonian's responsibility to inform the American public about the latest scientific and technological discoveries.

The Smithsonian is uniquely different from a government agency or a university in that federal appropriations provide the core support for our science efforts, museum functions, and infrastructure, while trust resources, including external grants and private donations, provide the support for new discoveries and investigations, and the global exchange of new ideas. This combination of support has allowed the Smithsonian to produce outstanding scientific research that is flexible, independent, and capable of exploring potentially high-risk areas of inquiry. Today, the Smithsonian is the largest museum and research complex in the world, with vast collections far exceeding the breadth and depth of those belonging to other institutions.

Throughout its history, the Smithsonian has set a precedent for endowed foundations that have supported scientific research as a primary goal—rather than as secondary to other missions, as found in government agencies and universities. One of the greatest strengths of Smithsonian science is its ability to take a long-term, synthetic, big-picture perspective on scientific issues, such as the origin of the universe and the effects of globalization on the environment.

This view is crucial for addressing many of the most profound scientific questions challenging our world today, such as how fast species are becoming extinct and whether we are alone in the universe. Smithsonian science is capable of concentrating resources in the form of scientists, curators, educators, museums, and research facilities on many of these profound questions. Every civilized nation has a museum, and there are many research organizations, but as Joseph Henry, the first Secretary of the Smithsonian, declared in the Institution's 1876 annual report, 'there is but one Smithsonian Institution.'

The Smithsonian Astrophysical Observatory is the largest and broadest astrophysical research institute in the United States, and the Smithsonian Tropical Research Institute is the world's premier tropical research facility. The unique and irreplaceable collections housed at the National Museum of Natural History and the National Zoological Park make the Smithsonian an internationally important research center in many areas. Utilizing its unique site on Chesapeake Bay, the nation's largest estuary, the Smithsonian Environmental Research Center has led groundbreaking studies in the ecological dynamics between land and sea. And Smithsonian geologists at the National Air and Space Museum are international leaders in the exploration of the Moon and Mars.

The ability of Smithsonian science to undertake different kinds of research using different approaches in different settings makes it unique. Its distinctive combination of talent, collections, and resources makes the Smithsonian Institution an invaluable asset for leading America's exploration, discovering and understanding our natural world and our place in the universe, and inspiring the public."

The recent strategic plan of the National Zoo places it directly in line with the overall strategy of the Smithsonian Institution. It states our mission as "We are the nation's Zoo, providing leadership in conservation science. We connect people with wildlife through exceptional animal exhibits, explore solutions through science-based programs, build partnerships worldwide, and share our discoveries. We educate and inspire diverse communities so they become part of this commitment to celebrate, study, and protect animals and their habitats." We are all excited about moving forward, both to expand existing scientific programs and initiate new ones.

I encourage you to learn more about the Zoo's science programs on our website at **http://nationalzoo.si.edu/ConservationAndScience/**, and look forward to sharing our progress with you in the months ahead.

Sincerely,

David L. Evans

David L. Evans
Under Secretary for Science, Smithsonian Institution,
and Interim Director of the Smithsonian's National Zoological Park

Notes&News

All photos this page: Jessie Cohen/NZP

The first litter of cheetah cubs born at the Smithsonian's National Zoo rest while with their mother, Tumai, watches over them.

Animal News

November 23, 2004, was a historic day for the Smithsonian's National Zoo. That morning, four-year-old **cheetah** Tumai, whose name means "hope" in Swahili, gave birth to the first cheetah litter born at the Zoo in its 115-year history. Tumai's four cubs, two males and two females, do bring hope for their endangered species.

Tumai and male Amadi were bred in August following recommendations from the American Zoo and Aquarium Association's Species Survival Plan for cheetahs (*Acinonyx jubatus*). Like all male cheetahs, ten-year-old Amadi did not help care for the cubs. A few weeks after their birth, he suffered from chronic kidney failure, a common illness in older, captive cheetahs. Despite the intensive medical care that he received, his condition worsened and he was euthanized in early December. In fathering the cubs he left a genetic legacy that will be passed to future generations of cheetahs. Learn more about the cubs and watch them on the Cheetah Cams at **www.fonz.org/africansavanna.htm**.

But the cubs aren't the only babies at the Zoo. Nineteen **leopard tortoises** (*Geochelone pardalis*) hatched at the Reptile Discovery Center in late 2004 and some went on exhibit soon after. They have black, reddish-brown, and yellow markings on their shells that look like spots on a leopard's fur. In the wild, leopard tortoises live on the savannas of Africa, where they graze on vegetation.

The black bodies and red legs of the new **Vietnamese centipedes** (*Scolopendra subspinipes*) at the Invertebrate House are also quite striking. These formidable predators each have 21 body segments, and each segment has one pair of legs. Using one specially modified pair of front legs, they inject venom into their prey, which in the wild includes insects, small mice, and even geckos. Vietnamese centipedes live in tropical and subtropical habitats throughout Southeast Asia and were introduced to Hawaii before 1850.

And in the Small Mammal House, two new **black and rufous giant elephant-shrews** (*Rhynchocyon petersi*) are the first of their species ever on exhibit at the National Zoo. The four-month-old brothers came from the Philadelphia Zoo, where they were named Kidogo and Panya. They have long, slender snouts that twitch constantly, and they communicate primarily through scent. Their species' taxonomic history is tangled: Scientists once placed them in the order Insectivora with true shrews, and later associated them with ungulates, primates, and rabbits. Thanks to modern molecular techniques for studying evolution, biologists now classify them in their own order, Macroscelidea, in the superorder Afrotheria, which includes elephants, the aardvark, and tenrecs. Black and rufuous giant elephant-shrews are endangered in their native Kenya and Tanzania. With Kidogo and Panya, National Zoo staff hope to participate in elephant-shrew research projects.

Get the scoop on Zoo scientists' latest groundbreaking discoveries at **www.fonz.org/science.htm**.

Spring Celebrations

For more information on special celebrations at the National Zoo, visit **www.fonz.org/events.htm**.

North American Wildlife Celebration

March 12–13—10 a.m. to 4 p.m.*

**Please note that the dates for this event changed since the printing of the 2005* ZooGoer *Calendar.*

At this free event, North American animals in the Zoo's Beaver Valley—including gray seals, a California sea lion, Mexican gray wolves, and bald eagles—are the stars. Activities include keeper talks, animal demonstrations, hands-on activities, and more.

African American Family Celebration

March 28—10 a.m. to 4 p.m.

For more than 100 years, families in the Washington, D.C., area have visited the Zoo on the Monday after Easter to socialize and enjoy the holiday. This year, FONZ invites you to a free, multicultural celebration featuring Easter-egg rolls, a food bazaar, storytellers, children's dance troupes, keeper talks, and much more.

Bird Fest 2005

April 30–May 1—10 a.m. to 4 p.m.

For the 13th year, the National Zoo celebrates International Migratory Bird Day and the return of millions of birds that winter in Latin America and the Caribbean. The festival will feature hands-on crafts and educational activities for families, live birds, interactive displays, and musical performances by Evergreen Theatre of Alberta, Canada.

Lecture, "Birdwatching in the 21st Century"

May 2—Book signing 7:30 p.m., lecture 8 p.m.

Renowned illustrator and author **David Allen Sibley** will share the creative process behind his acclaimed *Sibley Guides to Birds*, and the joys and challenges of birding and bird conservation. This free lecture is open to the public and is held in the auditorium of the National Zoo's Visitor Center. For more information on Zoo lectures and to RSVP, please visit **www.fonz.org/lectures.htm**.

Guppy Gala

May 13—6 to 8:30 p.m.

This annual fundraising event for kids is more fun than a barrel of monkeys. The whole family will enjoy arts and crafts, moonbounces, entertainment, and fantastic food amidst the Zoo's animal exhibits. Admission is $20 for FONZ members (adults and children) and $28 for nonmembers; proceeds benefit the Zoo's education programs. To purchase a ticket, go to **www.fonz.org/events.htm**.

National ZooFari

May 19—6:30 to 10 p.m.

ZooFari is the hottest ticket in town for gourmands who love to socialize in a wild and festive atmosphere. More than 100 of the area's finest restaurants and a select group of vintners will dazzle your palate, while musicians of all stripes will have you dancing under the stars. This year's theme, "Wing Ding," celebrates the Zoo's feathered fauna. Ticket prices for FONZ members are $120 before April 30, and $130 beginning May 1. The nonmember ticket price is $150. Proceeds benefit Zoo projects and education programs. To purchase a ticket, go to **www.fonz.org/events.htm**.

Volunteer Corner

Jessie Cohen/NZP

A blue-gray tanager at the Zoo's Indoor Flight Exhibit.

Gemma Dehnbostel is a volunteer interpreter at the Bird House. Here, she describes the underappreciated wonders of the Indoor Flight Exhibit.

"I watch adults and children push their way through the swinging plastic doors of the Indoor Flight Exhibit in the Bird House and quickly come back out again. Throughout my volunteer shift I see people come and go, knowing they often don't realize what fascinating species inhabit that part of the Bird House. That's why I love talking to them about the natural history of birds. When I point out one bird, visitors often notice others on their own and begin to appreciate this special place.

I also look forward to the quiet days of winter, the best time of the year to spend time in the Indoor Flight Exhibit—one of my favorite sites at the Zoo. I enter the exhibit, and immediately the rest of the world falls away as I listen to the sound of water falling over the rocks and feel the humidity of this mini-rainforest on my skin. I stand quietly, waiting for the birds to present themselves. They inevitably do after a little time and some patience on my part. I hope more visitors will take the time to visit the Bird House. If they watch and listen, they may be able to experience a little of the exotic in their everyday lives."

If you'd like to volunteer at the National Zoo, please visit ***www.fonz.org/volunteer.htm*** *or call 202.673.4956.*

Ana Fuentes/USFWS

This California condor was raised in captivity as part of a recovery program for its species. Now wild, it soars over a canyon in the Los Padres National Forest in southern California. The first captive-bred California condors were released into the wild in 1992.

THE COMEBACK CONDORS

BY JEFFREY P. COHN

It was a hot, dry August day and Allan Mee was exhausted. He and two colleagues had hiked in 100-plus degree heat through dense, thorny California chaparral, over a dry creek bed, and up a 40-foot waterfall to a remote canyon in Los Padres National Forest west of Los Angeles. Still ahead of them stood a high, sheer cliff with a grassy knoll where a four-month-old California condor (*Gymnogyps californianus*) was stranded. The chick, one of five hatched in the wild in 2004, had fallen from its nest on a ledge 200 feet above the knoll. From the way the chick held its wing, Mee knew it was broken.

After two unsuccessful attempts, Mee scaled the cliff face, reached the chick, taped its wings to prevent further damage, and carefully placed it in a folded cloth specially designed to hold condors. Then he slowly lowered the injured bird to his colleagues below. Completing the seven-hour rescue mission, the team retraced its steps out of the canyon to a waiting helicopter for a flight to the Los Angeles Zoo.

"We had to get that chick out of there," says Mee, a San Diego Zoo ornithologist who studies and monitors California condors in the wild. "I had watched that chick since before it hatched. It would have died if we had not been there. That would have been devastating. It's difficult not to get emotionally involved [with the condors]. I want to see those birds back out there as a viable species in the wild."

Once on the verge of extinction with no birds left in the wild, California condors are on the road to being a viable species once again. The condor population now totals 246, including 114 in the wild. Indeed, there are more condors in the wild today than at any time in at least 50 years. Nearly all of those birds have been hatched at captive breeding centers at the Los Angeles Zoo, San Diego Wild Animal Park, the World Center for Birds of Prey in Boise, Idaho, and most recently the Oregon Zoo in Portland. They have been released at nine separate sites in California and Arizona and one in Baja California in Mexico.

Further, the birds are following their species' old routes, exploring their old haunts, and finding some of their own food. They have even begun to breed and to fledge chicks in the wild. And they have done all that despite continued problems, dangerous juvenile behavior, and changes in how condors are raised and released into the wild. "Two decades ago we were not sure condors would make it," says Michael Wallace, a San Diego Zoo biologist and leader of the California Condor Recovery Team, an advisory panel to the U.S. Fish & Wildlife Service (USFWS). "It's been a slow process, but condors are tough. They're not doing too bad."

Not bad, maybe, but saving condors has not been cheap. The USFWS alone has spent more than $23 million since 1990 on the birds. Of that, $5.6 million went to The Peregrine Fund, which manages the Boise, Idaho, breeding center and the condor release program in Arizona. The Peregrine Fund has devoted $6.6 million of its own funds to the condor program since 1993. The San Diego Zoo has tossed in another $6 million. No figures are available for the Los Angeles Zoo.

Why anyone would want to save California condors might, at first glance, be a mystery. Admittedly, they are not much to look at. Unlike their cousins the Andean condors (*Vultur gryphus*) with their white neck fluffs, California condors are mostly a dull black. Their featherless heads and necks, oversized feet, and blunt talons are hardly signs of beauty or strength. And their carrion-eating lifestyle turns many people off.

That negative image vanishes when the birds take flight. With wingspans up to nine-and-one-half feet and weights up to 28 pounds, California condors are North America's largest fully flighted birds. In the New World, only Andean condors are bigger. California condors can soar almost effortlessly for hours, sometimes covering hundreds of miles in a single day. They need flap their wings only occasionally to take off, change direction, or find a band of warm air known as a thermal to carry them higher.

California condors once ranged from British Columbia in Canada south to Baja and east across the southern United States to Florida and New York. By the time Europeans reached California, however, condors were limited to the mountains along the Pacific Coast. By 1940, perhaps a hundred remained, all confined to a U-shaped region in the mountains and foothills north of Los Angeles. By the early 1980s they numbered but 21.

Why anyone would want to save California condors might, at first glance, be a mystery.

Spencer Weiner/USFWS

California condors were federally listed as endangered in 1967, the same year this condor, Topatopa, was brought into captivity.

Why California condors almost disappeared is not entirely clear. Probably never plentiful anywhere, their numbers and range may have started to decline with the disappearance of such Ice Age behemoths as mammoths and giant ground sloths some 10,000 years ago. More recently, ranchers and hunters sometimes shot or poisoned condors, under the mistaken impression that the birds killed livestock. And, as Los Angeles and other California cities have grown, suburban housing tracts, office buildings, industrial parks, strip malls, and roads have replaced the open range where condors often found food.

Worse, when scientists began monitoring and studying wild condors in the 1980s, they discovered that at least some of the birds were dying of lead poisoning. Condors and other scavengers sometimes ingest lead fragments from bullets in the carcasses of deer and other animals shot but not retrieved by hunters, or from gut piles left after an animal is cleaned. Lead can build up to lethal levels in the birds' bodies, unless people intervene and treat the condors with a chemical blood-cleaning procedure called chelation. At least three condors died due to lead poisoning in the 1980s.

The USFWS and several private groups launched a major effort to save California condors beginning in 1979. Land was set aside to protect the birds and other wildlife. A captive breeding program

was started at the Los Angeles Zoo and San Diego Wild Animal Park with eggs and chicks taken from the wild. And systematic studies of wild and captive condors began. Nevertheless, when six of the last 15 wild condors died or disappeared between 1984 and 1985, USFWS officials decided to capture the remaining birds. The last wild condor was taken into captivity in 1987.

Based on studies of wild condors, scientists and zookeepers knew that if a pair lost an egg, the female would often lay another. To speed up reproduction—pairs usually produce only one chick every other year—keepers removed the first and sometimes the second egg each captive pair laid, artificially incubated them, and raised the chicks using hand-held puppets that resemble adult condors to minimize their familiarity with people. Condor parents raised the chicks from subsequently laid eggs. All told, 314 California condors have been hatched in captivity since 1988. More than 90 percent of those chicks survived to fledging.

Mike Wallace

Biologists help a California condor chick hatch.

With the captive population growing, captive-hatched California condors were released in Los Padres National Forest beginning in 1992. Unfortunately, those first releases did not go well. Five of the 13 released condors died, four from flying into power lines. Others, engaged in what Wallace calls "goofy teenage behavior," landed on houses and garages, walked across roads and airport runways, sauntered into fast-food restaurants, and visited picnickers and fishermen. Although these behaviors were dangerous, Wallace thinks they reflected the birds' innate curiosity. None of these condors suffered harm, and all remaining birds were recaptured in 1994.

Condor biologists and zookeepers decided to try something different. Rather than just releasing the condors, they conditioned the birds to stay away from people and power lines. The keepers made any contact with humans a nasty experience and wired wooden poles in the enclosures to shock any condor landing on them. Later, instead of being raised solely with others their own age, condor chicks were socialized into a group that included adult birds. The adults served as role models for the chicks, pecked at them to keep the youngsters in their place, and discouraged juvenile misconduct.

It worked. Beginning in 1995, condors were released into the wild again at Los Padres. Later releases came in the Ventana Wilderness Area and Pinnacles National Monument in central California, along the Vermilion Cliffs north of the Grand Canyon in Arizona, and in the 10,000-foot-tall San Pedro de Martir Mountains in Baja. Altogether, 185 California condors have been released in the wild, with 114 still flying free.

While problems remained, the released birds exhibited fewer juvenile tendencies, especially as the older ones reached sexual maturity and their interests changed. These birds, along with some older condors captured in the 1980s that were no longer needed for captive breeding and were later restored to the wild, now serve as mentors to more-recently released birds. Additionally, condors are now released when 18 to 24 months old, not six as before.

Today, the wild condors are mostly acting like, well, wild condors. In 1999 one Los Padres female flew 160 miles to the north and found the Ventana condors. Two years later the Ventana birds began flying south to Los Padres. Now, birds from the two populations freely go back and forth to visit one another. Two Ventana females have even mated with males from and established nests in Los Padres. The chick with the broken wing hatched in one of those nests. It is scheduled to be released in 2005. Showing that old ties are not forgotten, both females revisit Ventana on occasion. In their travels, the birds have discovered many of the canyons, roosting and nesting sites, and feeding areas used by condors for millennia.

Meanwhile, Los Padres condors have flown 150 miles east following the San Rafael, San Gabriel, and Tehachapi mountains to the Sierra Nevadas in eastern California, an area once regularly visited by condors. Similarly, the Arizona condors freely move throughout the Grand Canyon as well as north to Zion National Park in southwestern Utah and east to the Fort Apache Indian Reservation in eastern Arizona. Some condors stay away for days or weeks. One daring Arizona female even undertook a 620-mile, 12-day round-trip flight from the Vermilion Cliffs to Flaming Gorge National Recreation Area in southwestern Wyoming and back.

Moreover, the released condors are now finding at least some of their own food. It's a great achievement, but it exposes the birds to lead poisoning. Researchers and field technicians still provide carcasses, mostly stillborn calves donated by local ranchers, to ensure that the condors get clean, lead-free food. Notwithstanding the handouts, deer, elk, coyotes, beaver, and livestock carcasses now make up at least 15 to 20 percent of the condors' diet in Arizona, says William Heinrich, The Peregrine Fund's species restoration manager.

Most important for restoring the species to the wild, the free-flying condors have begun to lay eggs and raise chicks. Indeed, a chick that hatched in 2003 on a remote ledge in the Grand Canyon in Arizona was the first condor to fledge successfully in the wild in two decades. Three more chicks successfully fledged last year, one in California and two more in Arizona. Also surviving at the Los

Angeles Zoo is the wild-hatched chick with the broken wing. Beyond hatchlings and fledglings, no juvenile or adult condor has died in the wild since October 2003. Only one had to be recaptured because of behavioral problems since 2001, says Jesse Grantham, a USFWS senior biologist.

Despite these successes, problems remain. Of the 18 eggs laid in the wild so far, only six chicks survived. Most died after their parents fed them bottle caps, glass shards, pieces of plastic, and other man-made objects that fatally perforated or blocked their intestines. No one knows why. Perhaps the inexperienced parents simply did not know better. Maybe condors are naturally curious birds that investigate and pick up objects. Or the adults may mistake man-made objects for bone chips fed to chicks for their calcium content. Biologists at Los Padres have added bone chips to the condors' food since 2002.

Another problem relates to human hunters and urban sprawl. Hunters have shot at two released condors. One of those birds, called AC-8, was one of the last wild condors taken into captivity in the 1980s. She was killed during a sponsored hunt in 2003 at El Tejon, a 272,000-acre ranch north of Los Angeles scheduled for development. The hunter, who had bragged of his success, was fined, lost his hunting license, and had his guns confiscated. Also, the developers of El Tejon have promised to limit housing density near condor ledges, create a 37,000-acre condor study area, and hire a wildlife biologist to help track and protect the birds.

All told, 314 California condors have been hatched in captivity since 1988.

Bruce Coleman Inc./Kenneth Fink

An adult California condor basks in the sun.

The most serious problem, however, remains lead poisoning. Virtually all wild condors have detectable lead levels in their blood, presumably from lead bullet or shot fragments. More than 60 percent had higher than normal amounts while 15 percent had potentially fatal levels that required immediate treatment, says Michael Fry, an environmental toxicologist and senior scientist at Stratus Consulting in Boulder, Colorado. Beyond the three condors killed by lead poisoning in the 1980s, four others released into the wild since 1995 died after eating lead fragments. Twenty-six others had to be recaptured and treated. They recovered and were later re-released. "The condors won't be truly self-sustaining until we have a lead-free environment," says Michael Stockton, a USFWS biologist.

Toward that end, the service has issued brochures and posters, and talked with individual hunters in California about how to keep condors and other wildlife lead-free. More recently, USFWS officials began working with other federal and state agencies, wildlife organizations, and hunting and shooting groups. The multi-year program is using focus groups to help develop educational materials, package inserts to accompany hunting permits, and magazine, newspaper, and newsletter articles. The program encourages hunters to switch to copper or other nonlead bullets and shot. A similar effort is under way in Arizona.

For hunters who still use lead bullets, the campaign will encourage them to find and clean any deer or other animals they shoot, and bury gut piles so condors and other scavengers do not find them. "We do not want to alienate hunters," says Marc Weitzel, the USFWS' condor project leader and manager of Hopper Mountain National Wildlife Refuge, where most Los Padres condors have been released. "We want to make the hunting community an integral part of the condor program. They are one of our partners."

Whether such voluntary efforts are enough to produce a lead-free environment in which condors no longer need to be fed by biologists remains uncertain. "Little or no progress has been made in resolving the lead problem," Fry states. Jeffrey Miller, the Center for Biological Diversity's wildlands coordinator, agrees. "Voluntary measures clearly won't do it all," Miller says. "It doesn't make sense to release condors into the wild without addressing the lead problem. It could negate the whole recovery effort."

Using its authority to regulate migratory birds, USFWS banned lead shot for waterfowl hunting in the 1980s. But the agency has no legal authority to outlaw lead bullets for deer hunting or lead shot for small animals, Weitzel says. Only state governments possess that power. The Center for Biological Diversity has petitioned the California Fish and Game Commission to require non-lead ammunition for deer and other hunting. Attempting a ban would be a "huge political and social challenge," states Mike Scott, a University of Idaho research scientist and former condor project leader.

For their part, hunters are ready to help protect condors from lead poisoning when they hear the right message from the right people, says Rick Patterson, executive director of the National Association of Shooting Ranges, a gun industry group. Can a voluntary program work? "Absolutely," says Patterson, if it is long-term. "Hunters have helped bring back a number of endangered species." The primary obstacle, though, remains the higher cost and aerodynamic deficiencies of nonlead bullets.

Problems aside, scientists have made several interesting discoveries studying condors, both in captivity and in the wild. One was the observation that young condors have to be socialized into a diverse group that includes others their age, older juveniles, and adults. Newly

Mike Wallace

This juvenile California condor's black head will turn reddish-orange as it matures. In captive breeding programs, juveniles are placed in social groups so they can learn appropriate behavior from adult condors.

fledged chicks naturally take their behavioral cues from older birds. With no older condors in the wild, the newly released birds, all usually in their first or second year, had only each other to emulate. "Adults provide leadership and direction on a basic social level," Wallace says.

Another finding concerns the bonds that scientists assumed adult condors formed as they paired upon reaching sexual maturity at about age six or seven. Common wisdom held that condors formed monogamous pairs that remained stable for life. Not necessarily so, says Mee, the San Diego Zoo ornithologist. In fact, young condors may be more promiscuous and deviate from the norm more often than previously thought.

The first hint that this might be the case came in 2001 when one wild condor male paired with not one but two females, both of whom laid eggs. The only other previous record of such a *ménage a trois* occurred at the Los Angeles Zoo. With only one male to help incubate two eggs, the field biologists removed both eggs from the nest and took them to the Los Angeles Zoo for hatching. One of the females has since left that male and found another mate.

Marlon Concepcion/USFWS

In fact, both male and female wild condors often have sex with condors other than their mates. Mee says 23 percent of all condor matings in the wild took place between a paired bird and a bird that was not its mate. Among other bird species, the highest known occurrence of what wildlife biologists call "extra-pair" mating is seven percent. The birds' youth, the tenuous nature of early pairings, and either the male or female seeking another mate after the current one proves unable to raise chicks may explain extra-pair mating among condors. Or it may have something to do with social stature. Mee notes that 75 percent of the known extra-pair matings or displays are done by the highest-ranking male and most of the rest by the second highest.

Whatever the reason, the promiscuous sex lives of some wild condors could affect continuing efforts to save the birds. Wildlife biologists and zookeepers maintain meticulous records on all condors, including their parentage. That helps ensure as genetically diverse a population as possible given the few condors from which all of today's birds descend. Now, though, knowing who fathered which chicks may be more difficult, especially when no observers are present to record matings. It may also mean that only a few males are siring most of the wild chicks, potentially reducing genetic diversity.

In the end, the condors are beginning to approach the recovery program's stated goal of a self-sustaining wild population of 150 birds in each of two sites—southern California/Baja and Arizona—plus another 150 in captivity. Still, "we have a long way to go," notes the USFWS' Stockton. "We saved those birds from extinction, but we won't know whether we've successfully restored them to the wild for many years," he says. "I hope so. Those wild condors are beautiful animals." Z

—Jeffrey P. Cohn is a freelance writer who lives in Takoma Park, Maryland, and specializes in conservation subjects.

The newly discovered marine worm *Osedax frankpressi* is one of only two species known to feed on the fats and oils inside whale bones. It has no mouth or stomach; instead, the green "roots" visible in this lab photo grow deep into the bone and, with the help of symbiotic bacteria, extract nutrients.

A Whale of a TALE

BY ROBIN MEADOWS

Greg Rouse

Life can be found in the most extreme environments, from hot springs to frigid glaciers to salt crystals. One of the strangest forms of life was recently found on a whale carcass in the deep sea. On a routine survey of a marine canyon off California, scientists discovered two closely related species of tubeworms that live only on whale bones at the bottom of the ocean. These worms have a unique way of feeding: They grow "roots" into the bones, and these roots contain bacteria that break down the oils in the bone marrow and so provide the worms with nutrients. Bone-eating worms are the first kind of animal known to have symbiotic bacteria that live on oils. They also have a unique way of developing: Only the females grow roots into bones, while the males resemble larvae all their lives and are essentially tiny sperm-producing machines that live inside the females' tubes.

"Everything we looked at was a surprise," says Robert Vrijenhoek of the Monterey Bay Aquarium Research Institute (MBARI) in Moss Landing, California, who led the team that found the bone-eating worms in 2002. "Every time we find something new like this, it opens a window on what forms of life are possible," he adds, noting that the idea of life on other planets was made far more plausible by the 1977 discovery of life at deep-sea hydrothermal vents. These hot-spring habitats are crowded with tubeworms and other extreme forms of life that get their energy from sulfides rather than sunlight.

Whale carcasses that sink to the bottoms of oceans around the world are another source of concentrated nutrients in the otherwise nutrient-poor deep sea. Like hydrothermal vents, these "whale falls" are almost completely covered with tens of thousands of living creatures. Besides being fascinating in their own right, whale falls may help explain mysteries of deep-sea ecology and evolution, such as how some animals reached remote hydrothermal vents in the first place. Learning more about the deep-sea floor is critical to protecting its remarkable biodiversity, which may be comparable to that of tropical rainforests.

Besides being fascinating in their own right, whale falls may help explain mysteries of deep-sea ecology and evolution.

Deep-sea Basics

The deep sea starts at about 3,300 feet below sea level and goes all the way down to about 36,000 feet at its deepest point, the Mariana Trench, in the Pacific Ocean near Guam. The depth of the Mariana Trench is greater than the height of Mount Everest, which is the tallest mountain in the world at 29,035 feet above sea level.

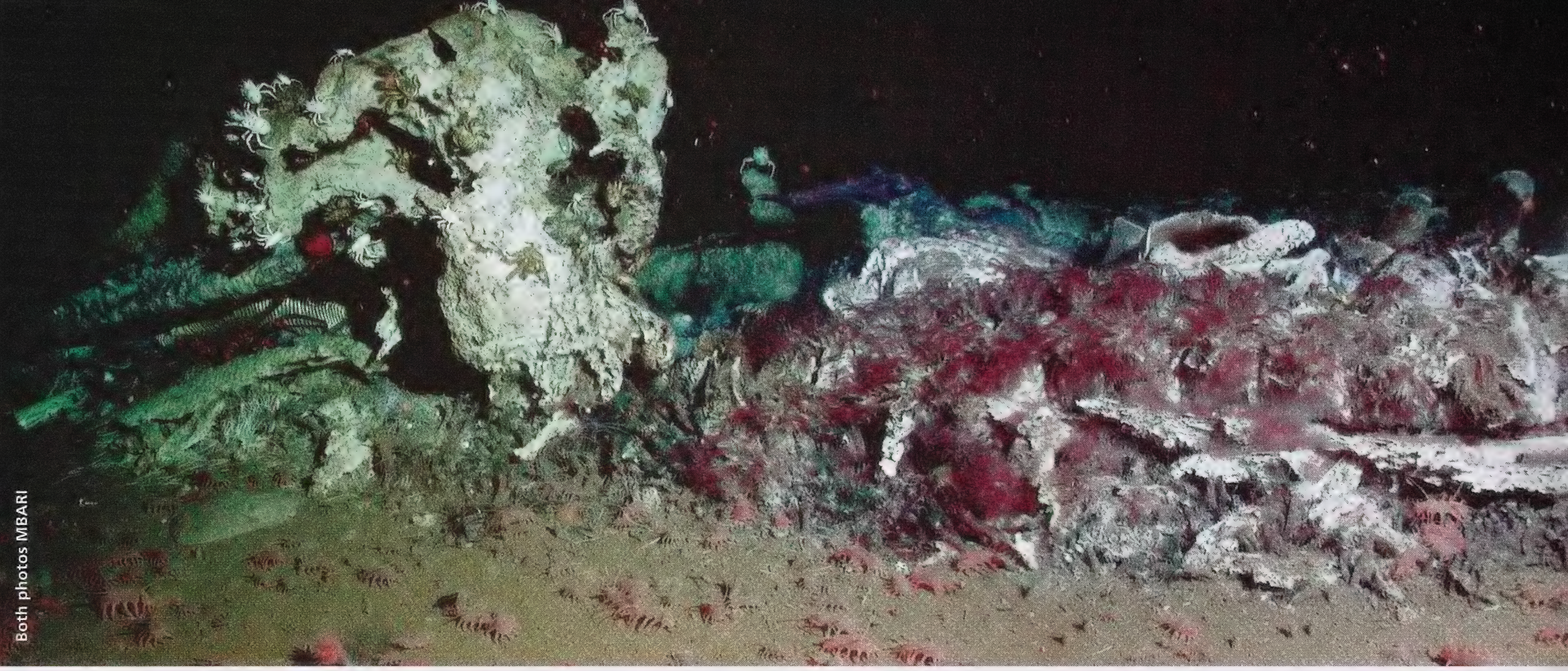
In addition to being remote, the deep sea is vast. "It's the largest habitat on Earth and may harbor a substantial part of [the Earth's] biodiversity," says whale-fall expert Craig Smith of the University of Hawaii. The deep-sea floor alone covers about 60 percent of the Earth's surface and about 116 million square miles, making it one of the most extensive ecosystems in the world. Its sheer size and inaccessibility also make it one of the least-known ecosystems.

But what we do know makes us want to learn more. One of the biggest mysteries is why so many species inhabit the deep sea. "By some estimates, there may be as many as ten million animal species in deep-sea sediments, rivaling the diversity of tropical rainforests," says Smith. Intuitively, it seems that the opposite would be true. The deep-sea floor is a tough place to live—it's completely dark, is under enormous pressure, and for the most part, is near freezing and contains few nutrients. Even so, there are thought to be many more bottom-dwelling species in the deep sea than in shallower waters.

While biodiversity is high on the deep-sea floor, animals there are typically much smaller and less abundant than those in shallower waters. This is not surprising because animals in most of the deep sea live on "marine snow": plankton and other organic debris that fall from surface waters to the bottom of the ocean.

There are exceptions, however. Some deep-sea floor habitats are crammed with animals that may be gigantic compared to their shallow-water relatives. The most famous of these habitats are the hydrothermal vents on submarine mountain ridges, which are packed with foot-long clams, nine-foot-long tubeworms with red plumes, and other fantastical creatures.

The reason there is so much life at hydrothermal vents is that they spew out sulfides and other energy-rich minerals. Most ecosystems are based on photosynthesis: Plants, algae, and some bacteria use the energy in sunlight to turn carbon dioxide into the organic compounds that form the basis of most known life. However, hydrothermal vent ecosystems are based on chemosynthesis: Bacteria use the energy in sulfides and other minerals to make organic compounds. Some of these bacteria live in seawater and form dense mats, while others live symbiotically within the tissues of animals and provide their hosts with food. Giant tubeworms, for example, have no mouths or guts, but instead have a large organ full of symbiotic bacteria that produce nutrients for them. Similarly, the gills of hydrothermal vent clams and mussels are also full of symbiotic bacteria.



Both photos MBARI

The whale fall pictured above left was found by MBARI scientists in Monterey Canyon. Red *Osedax* worms carpet its body while pink sea cucumbers scavenge on the sea floor nearby. At right, a closeup shows *O. frankpressi* worms growing on a whale bone. Their red and white plumes may function as gills.

Whale-fall Basics

Whale carcasses are another deep-sea habitat that is crammed with life. Whale falls can provide as much organic material as a thousand years of marine snow, and a single skeleton can support more than 40,000 individual animals including shellfish, amphipods, and worms.

In 1987, a decade after hydrothermal vents were first discovered off the Galapagos Islands, biologists learned that whale falls also support animals that get their food from symbiotic bacteria. Led by the University of Hawaii's Smith, a team of scientists made this discovery on a blue whale (*Balaenoptera musculus*) skeleton they found at about 4,000 feet deep in the Santa Catalina Basin off the coast of southern California. The scientists found the bones were covered with clams and mussels containing symbiotic bacteria that live on sulfides. While the sulfides at hydrothermal vents are in the water that spews from beneath the sea floor, the sulfides at whale falls are produced by bacteria that decompose oils inside whale bones.

Animals with symbiotic bacteria have inhabited whale falls for ages. In the Pacific Ocean, 30-million-year-old whale fossils have been found with mussels attached to their bones, and these mussels presumably had symbiotic bacteria because all of their close relatives do today. Intriguingly, animals with symbiotic bacteria may also have lived on skeletons in the deep sea well before the time of whales, which first appeared about 40 million years ago. Mollusk fossils have been found near 200-million-year-old fossils of large marine reptiles, including ichthyosaurs and plesiosaurs.

Whale skeletons support so much life in the deep sea because they contain an enormous amount of oil. Large whale bones can be more than 60 percent oil by weight, and the skeleton of a 90-ton whale, for example, is estimated to contain five tons of oil. Depending on the size of the whale, its bones can contain enough oil to support sulfur-loving species for as long as 80 years.

> Whale falls can provide as much organic material as a thousand years of marine snow, and a single skeleton can support more than 40,000 individual animals.

So far, 407 species have been found on whale falls. But there are probably a lot more, because most of what we know about whale falls comes from only 20-odd specimens—either skeletons found by chance on the sea floor, or skulls and other parts that were trawled up from the depths. In addition, while whale falls have been found scattered around the world, most of those that have been studied are in California waters. Just as the species at hydrothermal vents vary in different parts of the world, Smith expects that whale fall species will vary around the world. In keeping with his expectation, museum specimens of animals found on whale bones off New Zealand are different from those found on whale bones off California.

The fact that so many whale-fall species are known from so few specimens suggests that whale falls have more species than hydrothermal vents. While vents have more known species right now—600 worldwide—they have also been more intensively studied than whale falls. As we learn more about whale falls, the numbers of known species at whale falls could surpass those at hydrothermal vents.

Likewise, the number of species unique to whale falls is likely to rise above the 30 that are known today. The existence of these whale-fall specialists raises an interesting question: Because whale skeletons are isolated habitats that support life for a limited time, how do the species that depend on them get from one whale fall to another?

Smith thinks that whale falls are close enough together to form habitat "archipelagos." Whale carcasses are likely to be concentrated along migration routes and in feeding and calving grounds, which means they are probably close enough together for marine larvae to traverse them. For example, Smith estimates that the deep-sea carcasses of gray whales (*Eschrichtius robustus*) off the west coast of North America are roughly four to ten miles apart, which is well within range of marine larvae dispersal. Even greater distances could

also be within their range: Some marine larvae can survive as long as nine months and so may be able to disperse more than 500 miles.

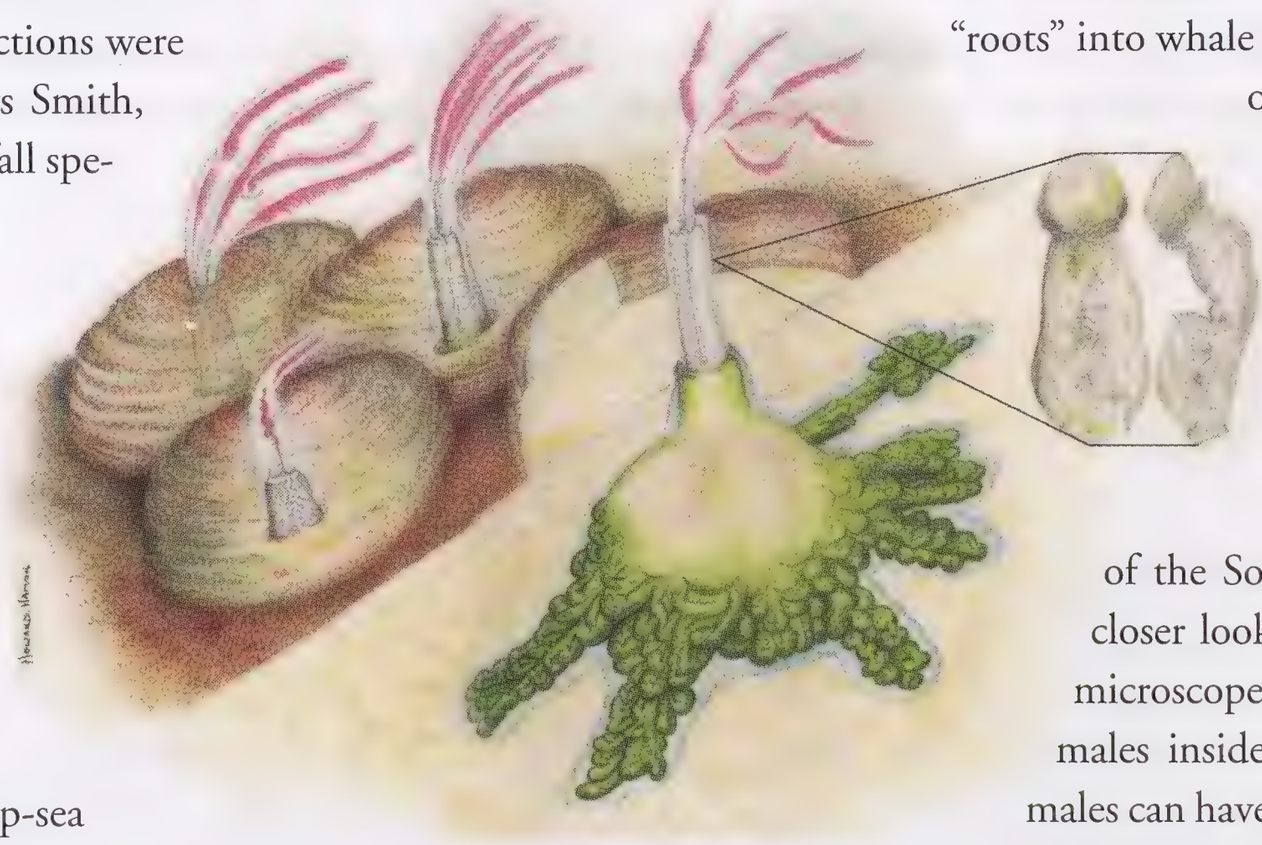
The existence of species that are unique to whale falls raises another question: How did commercial whaling affect them? Massive commercial whaling began in the 1800s and continued into the 1900s. Despite the 1982 International Whaling Commission's moratorium on commercial whaling, today many whale populations are estimated to be at only ten to 25 percent of their historical levels. Fewer whales means fewer whale falls, which in turn means less habitat for whale-fall species. Habitat loss can make species more vulnerable to dying out, and Smith believes that intensive commercial whaling has already driven some whale-fall specialists to extinction. "It's likely that the first extinctions were due to the onset of whaling," says Smith, adding that "extinctions of whale-fall specialists are probably ongoing."

Extreme Forms of Life

Learning more about species unique to whale falls may also teach us more about the extremes of life, which increases our understanding of the range and limits of life on Earth—and possibly on other planets. The bone-eating worms that live on deep-sea whale skeletons are a prime example.

Named *Osedax*, which is Latin for "bone-eater," these worms were found by a team of MBARI scientists on a gray whale carcass at a depth of nearly 9,500 feet, in the waters of Monterey Canyon off California. The whale bones were covered with short tubeworms that turned out to be two new species: *Osedax rubiplumus*, which is up to two-and-a-half inches long and has red plumes, and *Osedax frankpressi*, which is up to an inch long and has red plumes with white stripes. The plumes are thought to act as gills, and neither species has eyes.

Albeit on a much smaller scale, bone-eating worms resemble the giant tubeworms at hydrothermal vents, and it turns out they are related. Both types of worms are members of the family Siboglinidae, and they lack mouths and guts and depend on symbiotic bacteria for nourishment. Here the similarities end, however. Vent tubeworms have a large internal organ called a trophosome that is full of bacteria that live on sulfides. In contrast, MBARI researcher Shana Goffredi found that bone-eating worms have a large external organ full of bacteria that live on oils. This organ grows "roots" into whale bones, so the bacteria can feed on oils in the bone marrow and in turn supply nutrients to their worm hosts.



An illustration of large female *O. frankpressi* worms. The individual in the foreground is depicted on a cross-cut of a whale bone; her green "roots" grow below the surface of the bone. The detail shows a magnified view of tiny males living inside her tube.

Unlike vent tubeworms, bone-eating worms all appear to be female at first glance. However, when worm specialist Greg Rouse of the South Australia Museum took a closer look at the new worms through a microscope, he saw that there were dwarf males inside the females' tubes. Large females can have more than 100 males attached to their bodies with tiny hooks.

Females with attached males are nothing new in the deep sea. A famous example is the female angler fish—in this species, dwarf parasitic males bite females and hold on, eventually fusing with their mates' bodies. Bone-eating worms go to an even further extreme than angler fish in the game of attachment. "The males are essentially embryos

Greg Rouse/Painting by Howard Hamon

with sperm," says Vrijenhoek. "They're pushing sexual maturity as far back as possible."

In hopes of learning more about how bone-eating worms reproduce and develop, Vrijenhoek and his team sank a beached 56-foot blue whale in nearly 3,000-foot-deep water in October 2004. The scientists are waiting to see if bone-eating worms will also colonize a whale fall in shallower water, where they would be easier and cheaper to study. This approach has worked before—worms in the same family have been found on whale carcasses that Smith sank in relatively shallow waters off California and Sweden.

The MBARI team is full of questions about the bone-eating worms. For example, do larvae that settle on bones become females, while larvae that land on female worms become males? There is a precedent for this. Sex is environmentally determined in some other marine worms, and crowding usually leads to males. Alternatively, it is possible that males are the sons of the females they are attached to. "Anything goes here, we just don't know what to expect," says Vrijenhoek.

C. Van Dover/NURP

Like *Osedax* worms, hydrothermal vent tubeworms harbor symbiotic bacteria in their bodies.

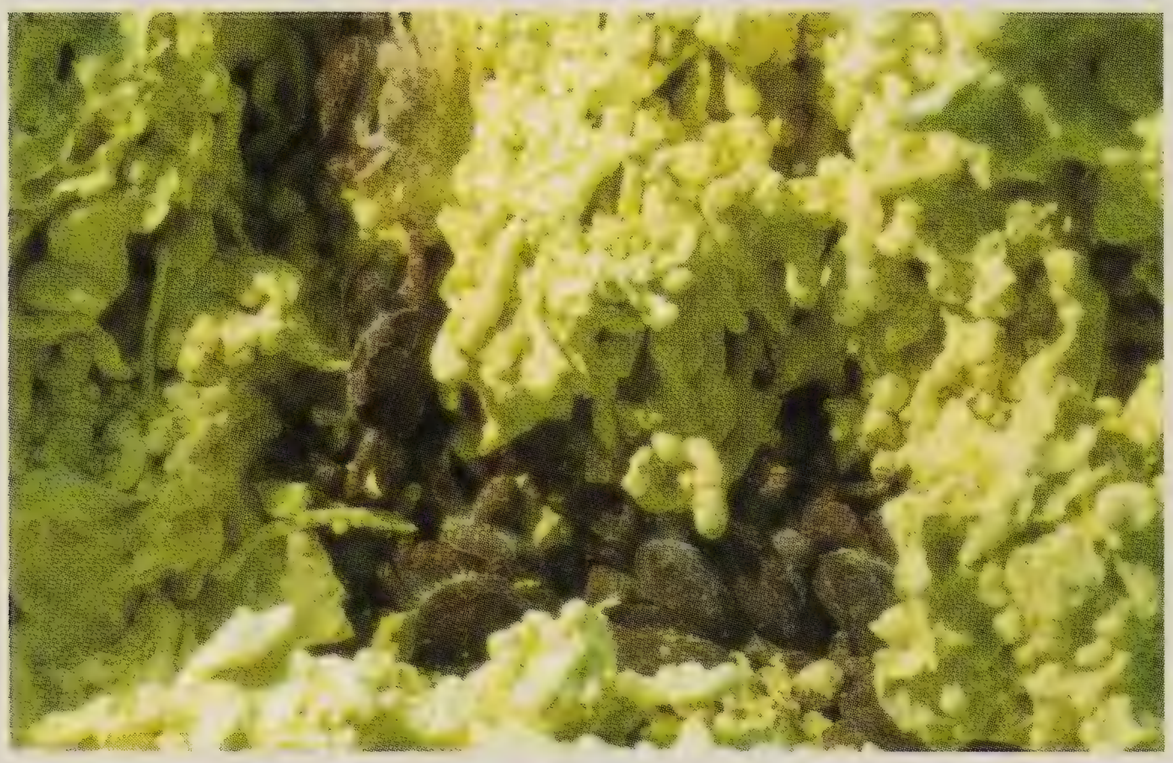
The scientists do know that the bone-eating worms are very successful. Analyses of their genetic variation indicate that, depending on the species, between 500,000 and a million female bone-eating worms contributed to the pool of larvae that colonized the Monterey whale fall. This is similar to population estimates for other deep-sea worms, suggesting that whale-fall habitats may be more abundant than previously believed, says Vrijenhoek.

Clues to Deep-sea Ecology and Evolution

Whale-fall species not only offer insights into the extremes of life—they are also helping scientists learn more about the ecology and evolution of life in the deep sea. For example, some species may use whale falls as ecological "stepping stones" to reach hydrothermal vents. The University of Hawaii's Smith and his colleagues have so far found that there are 11 species known to live at both whale falls and vents.

Some species may also use whale falls as ecological stepping stones to get from one vent system to another. This could explain why vents in different areas of the world have some species in common. Notably, there is an overlap of about ten species at the vents on the Juan de Fuca Ridge off Washington and British Columbia, and those in the East Pacific Rise off Baja California, Mexico. These vent systems are about 1,500

Vent Crabs: Shallow Opportunists



M.S. Jeng/Nature Publishing Group

***Xenograpsus* crabs gather in underwater crevices near shallow-water hydrothermal vents.**

Biodiversity abounds near deep-sea hydrothermal vents, which spew energy-rich sulfides and minerals that sustain life. But although most of the action—and the variety—of life at thermal vents is found in the deep, some organisms flourish in shallower extremes.

Take, for example, *Xenograpsus testudinatus*. These crabs live off the coast of Kueishan Island in northeastern Taiwan and inhabit crevices on the sea floor near shallow-water vents. Unlike deep-sea vents, which emit nourishing plumes of sulfides, the Kueishan vents discharge elemental sulfur and toxic volcanic gases into the sea. This creates a highly acidic and nutrient-poor environment that is not conducive to the chemosynthesis-based ecosystems found at deep-sea vents. The energy-rich sulfides are missing.

miles apart but could be connected by the carcasses of gray whales, which migrate from their winter feeding grounds in the Bering Sea to their summer breeding grounds in the Gulf of Mexico. In support of this theory, at least one of the species that lives at both of these vent systems (a clam) also lives on whale falls. Scientists may find other such examples as they study more whale falls around the world.

Similarly, some species may have used whale falls as evolutionary stepping stones from shallow waters to hydrothermal vents. This makes sense, because whale falls lie at intermediate depths between these two habitats. This theory could also explain why a species of mussel that is related to mussels in salt marshes and other shallow waters also lives near some vents: Smith and his colleagues found that whale falls have a mussel that is intermediate between the species at the other two habitats. DNA analyses suggest that the deep-sea mussel split from the shallow-water mussel roughly 30 million years ago, about the time that large whales evolved.

Why We Need to Understand the Deep Sea

Any insights that whale falls can give us into the deep sea are important because we know so little about this ecosystem. And understanding the deep sea is critical because, although remote, it is still intimately connected to the rest of the world. "It's the biggest sink for carbon dioxide, and understanding the global carbon balance is important for figuring out what to do about climate change," says Vrijenhoek. Carbon dioxide is the major "greenhouse gas" produced by people, and is linked to global warming.

Carbon dioxide is absorbed by the oceans' surface waters, where it is then taken up by photosynthetic plankton. Some people suggest we take advantage of this process to reduce global warming. The idea is to fertilize the plankton with iron, thereby increasing the plankton and so decreasing the atmospheric carbon dioxide. However, this plan could also decrease the amount of oxygen in the deep sea, which would cause problems. "If iron fertilization was on a large enough scale to decrease the carbon dioxide, it would probably create major anoxic [oxygen-deficient] areas where virtually all the deep-sea animals would die," says Smith.

If the deep sea became too oxygen-depleted, it might not be able to provide one of its key ecosystem services: nutrient recycling. Over the course of centuries to thousands of years, nutrients that fall into the deep sea as marine snow and other organic debris are recycled back to the surface. Animals and bacteria that live in deep-sea sediments return these nutrients to the sea water, and the cycle begins anew. This process yields upwellings rich in nitrogen, phosphorus, and other nutrients that support algae growing in the ocean's surface.

In contrast, the fate of carbon that falls to the deep sea floor is largely a mystery. "We don't know how much of it comes back up," says Vrijenhoek. Carbon does get spread around by animals in the deep sea, partly facilitated by whale falls, and he speculates that bone-eating worms and other abundant deep-sea species may play a significant role in the global carbon cycle.

Whale falls are likely to keep surprising and delighting us with new species like bone-eating worms, and increasing our understanding of the connections within the deep sea and maybe even between the deep sea and the rest of the world. These extraordinary habitats at the bottom of the ocean also remind us that there's still a lot we don't know about what goes on down there. And while the deep sea is vast enough that it can probably take a lot of use or even abuse, we still need to be careful about what we do to it. The deep sea is one case where out of sight should not mean out of mind. Z

—Robin Meadows is a contributing editor of ZooGoer. *She wrote about California's island fox in the July/August 2004 issue of the magazine.*

Scientists from Taiwan and Singapore wondered what *X. testudinatus* were eating in such a nutrient-poor environment. As reported in the December 30, 2004, issue of *Nature*, they discovered that the crabs are opportunistic feeders that take full advantage of their unusual environment.

M.S. Jeng/Nature Publishing Group

Kueishan Island, Taiwan.

At slack tide around Kueishan, when there is no current moving in or out, sulfurous plumes billow from as many as nine vents at once, killing everything in their path. Zooplankton caught in the deadly billows die and fall to the ocean floor like "marine snow." Suddenly the crabs swarm out of their crevices and, bombarded by a steady rain of dead zooplankton, begin a frantic feeding frenzy. By peeking into the guts of several *X. testudinatus* specimens the scientists confirmed that the crabs were indeed feasting heartily on the zooplankton (mostly ocean-dwelling copepods).

As soon as the currents around the vents pick up again, the sulfurous plumes shift, the rain of food ceases, and *X. testudinatus* retreat to their crevices. Scientists believe the crabs probably feed twice a day, following the pattern of Taiwan's semidiurnal tides. A second crab species, *X. novaeinsularis*, has also been observed feeding on the ocean floor, but thus far its diet remains unknown.

—Emily Huhn

THE CANARIES
INVADED ISLES OF WONDER

BY HOWARD YOUTH

Twenty million years ago, mild and misty *laurisilva* forest cloaked many parts of the world. But this "laurel jungle," as the name means in Portuguese, withered over the millennia thanks to climate change, leaving few living reminders. Last March, I stood within one of the largest remaining patches of *laurisilva* in the world, on the largest of the Canary Islands, Tenerife. Beneath a moss-bearded canopy of Canary Island laurel (*Laurus azorica*), holly (*Ilex canariensis*), and tree heath (*Erica arborea*), I watched a large, long-necked dove—an endemic Bolle's pigeon (*Columba bollii*)—clap off into the fog. At that moment, so far from the highways and hotels, I could easily imagine what this island was like before Spanish possession.

Bruce Coleman Inc./J.C. Carton

A tourist beach on the southern shore of Lanzarote, one of seven large islands in the Canary Island archipelago. Tourists are the latest of several waves of invaders that, over centuries, have altered the islands' ecosystems.

Bruce Coleman Inc./Massimo Borchi/Atlantide

A *laurisilva* forest on El Hierro, the westernmost Canary Island. El Hierro's nickname is *Isla Meridiana*, because for at least 1,500 years many geographers and navigators considered it to be the prime meridian.

The *laurisilva* forest holds fast to steep, craggy ranges that once also sheltered the Guanche people, the aboriginal Canary Islanders. The Guanches hunted the wily native pigeon I had just seen, until *they* in turn became quarry for invading hordes of Spanish soldiers beginning in the 1400s. In forests such as this one, Guanches resisted for decades, but in the end, Spanish weaponry—as well as diseases Europeans brought with them—prevailed. Sickened, enslaved, and finally interbred out of existence, the Guanches vanished by the 1600s.

The Canary Islands form an archipelago off the coast of present-day Morocco that includes seven major islands and a host of small rock islets. Today, the Canary Islands are outlying pieces of Spain.

Four waves of invasion have shaped this once-isolated place. First, the Canaries became a landing site for wayward wildlife from the far-off mainland. Next came the first human occupiers, the Guanches. Then came the conquerors, the Europeans, who used the islands as stepping stones for more distant exploration, while also colonizing the archipelago. Finally, modern-day travelers such as myself constitute a fourth wave of invasion—people who each year descend upon the islands in the millions via daily flights, ships, and ferries.

The Canary Islands, while not exactly what they once were, do retain much of their uniqueness. To biologists and botanists, they are the "Galapagos of Europe" because beyond the beach chairs, buffets, and bars live creatures found nowhere else—the descendants of the first invaders. In a general sense, the story of the Canary Islands mirrors that of many other archipelagos around the world that were colonized first by wildlife then by humans. In the details, however, it is a story unlike any other.

Castaways

Canarian wildlife have both European and North African affinities. Their ancestors colonized the islands from both regions, either via their own wing power or by hitchhiking on drifting debris washed from the mainland. The early animal and plant colonists, however, found *terra firma* only because successive volcanic eruptions created an underwater mountain range whose peaks eventually poked above the ocean surface, creating a part-wet, part-dry island chain.

The islands' volcanic origins are obvious from the air: Off the coasts of the easternmost islands Lanzarote and Fuerteventura, conical, treeless mountains rise from the blue-green water, their rims seeming ready to spew lava. The oldest island, Fuerteventura, dates back about 20 million years, while the younger, higher western islands of El Hierro and La Palma were formed as recently as one and two million years ago, respectively. The Canaries' most recent eruption occurred on La Palma in 1971, but almost certainly will not be their last.

Piecing together how and when species arrived on the islands and spread to other islands is challenging, speculative work. Biologists and botanists from a variety of international institutions prowl the Canary Islands' stony fields, cliffs, and misty forests, attempting to piece together species' pasts and presence. They examine fossils or head to the lab to compare genetic similarities or differences. Meanwhile, as

scientists try to get a fix on the past, the mechanics of evolution chug along, and the islands' wildlife are continually changing and facing new challenges to their survival.

Scientists have an easier time studying more recently formed islands or other isolated habitats where they can watch wildlife colonization as it occurs. Take, for example, three sites where scientists are tracking newly established plants and animals: the Indonesian island of Krakatoa, which emerged from the ocean via eruptions in 1883; the Icelandic island of Surtsey, which appeared amid a smoldering sea in 1963; and the site of a 1980 volcanic eruption at Mount St. Helen's in Washington, where animals and plants re-appeared after ash destroyed their ecosystem.

Within weeks of the Surtsey eruption, for example, gulls gathered on the island. Not long after, scientists found the first fungi that colonized the island, then bacteria, then vascular plants. Today, hundreds of gull pairs of four species nest there, and contribute to a growing island flora via their daily droppings, which infuse nutrients into the poor soil. Seeds carried by birds from nearby islands are also changing Surtsey's landscape.

The data collected from such places give scientists studying the Canaries a better idea of what may have happened there before and what is happening now. There is much to ponder: About a quarter of the islands' almost 2,000 vascular plant species are endemic, as are almost half of the 6,300 native arthropods, which include insects and spiders. Five bird species, along with dozens of subspecies, occur only in the Canaries.

Herpetologists revel in the islands' particularly diverse collection of lizards, all of which are endemic to the Canaries. After arriving on floating debris such as storm-driven trees, early gecko, skink, and lacerta colonists evolved into new species over the millennia. The lacertas (family Lacertidae) were particularly successful, radiating into small, medium, and large herbivorous and carnivorous species. Seven endemic species of the lacerta genus *Gallotia* now inhabit the islands; others have come to light from fossils.

Many herpetologists think that Canary Island lacertas evolved from an ancestor of the genus *Psammodromus*, whose living members now inhabit northwestern Africa and southwestern Europe, including Spain. The ancestral stock, so some hypotheses go, landed on the eastern islands, then spread west in a stepping-stone fashion of colonization and diversification. Biologists are still trying to untangle which species are most closely related, and from which species others may have evolved. Their work is now more challenging thanks to recent discoveries. For example, a new *Gallotia* species was found in 1996 on Tenerife; another, previously known only from fossil evidence, turned up alive in 2000 on the nearby island of La Gomera.

The Canaries share some species, and many closely related life forms, with other Atlantic islands with similar natural histories—islands that geographers lump together in the Macaronesian group. Aside from the Canaries, the Macaronesian islands include the Portuguese islands of Madeira, which lie to the north, the tiny Selvagens, situated between Madeira and the Canaries, and the farther-flung Azores and Cape Verde Islands. The plain swift (*Apus unicolor*), Berthelot's pipit (*Anthus berthelotii*), and the island canary (*Serinus canaria*)—ancestor of pet-store canaries—are among the animals found only within the Macaronesian group.

Herpetologists revel in the islands' particularly diverse collection of lizards, all of which are endemic to the Canaries.

Angelika and Siegfried Troidl

The ancestry of the Canaries' lacerta lizards, including this Tenerife lizard (*Gallotia galloti eisentrauti*), perplexes scientists.

The Second Great Invasion

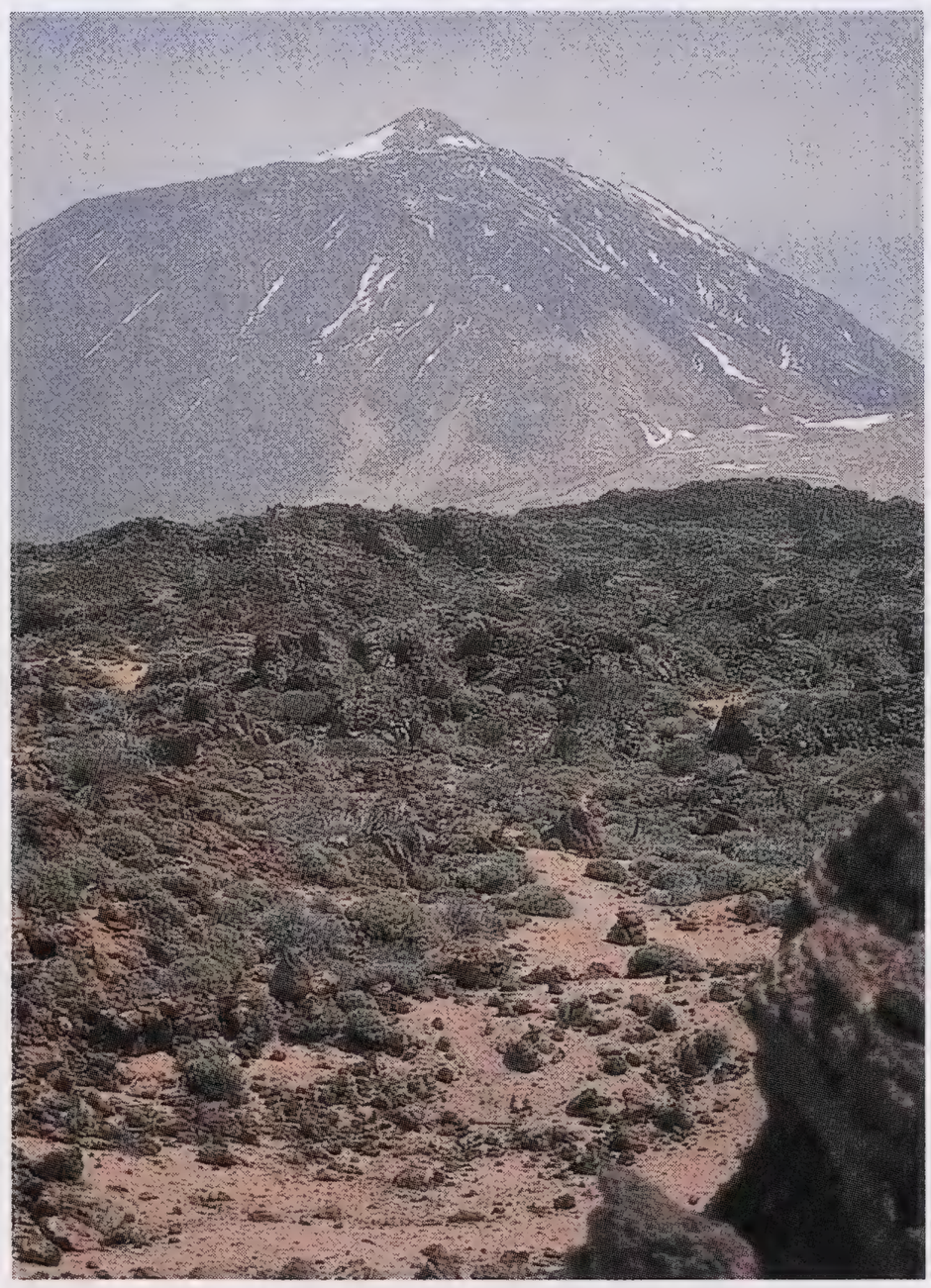
The day before my *laurisilva* visit, I sat in a jet descending toward Tenerife, looking out the window at a huge mountain that dominated the view. The surrounding low mountains seemed to bow to this snow-drizzled giant, called Mount Teide. During much of my exploration of the northwest corner of the island, I saw this 12,200-foot-tall volcano—Spain's tallest mountain—looming over a variety of landscapes, from Canary pine forest to barren lava fields. I wasn't the first to be impressed by it: The Guanches considered the mountain sacred and believed it was inhabited by a demon. Later, in the 1500s, a Dutch visitor wrote that it was "thought to be the highest hill that ever was found, for it may easily be seen at the least threescore miles in the sea."

Today, if you drive west from Tenerife's Rodeo Airport, you will see not only Mount Teide; you are also likely pass the town of La Matanza de Acentejo, which in English means "The Slaughter of Acentejo." There in 1494, Spanish warrior and explorer Alonso de Lugo launched 1,000 Spanish troops against the island's remaining Guanche people,

who had fled the lowlands to hide in the island's thickly forested mountains. At La Matanza de Acentejo, stone-wielding Guanches ambushed Lugo and his men, killing hundreds of soldiers.

A bit farther down the highway sits another town, La Victoria de Acentejo, where Lugo returned the next year with more forces, finally crushing the Guanche resistance. Tenerife was one of the last Guanche strongholds. Today, place names, a few words, and some mummies and other artifacts are all that remain of the Guanches. As historian and geographer Alfred W. Crosby wrote in his book *Ecological Imperialism: The Biological Expansion of Europe, 900-1900*, "They were, with the possible exception of the Arawaks of the West Indies, the first people to be driven over the cliff of extinction by modern imperialism."

When Europeans first arrived, an estimated 80,000 Guanches inhabited the archipelago. Most anthropologists believe that the Guanches originated from Berbers, who likely came over by boat from North Africa around 500 B.C.E. or earlier. They colonized the islands over centuries, and once settled, they apparently lost interest in plying the seas. Instead, they spent their days herding goats, collecting mussels along the shore, and tending crops such as barley and peas, the seeds of which they brought from the mainland.


Howard Youth

Tenerife's Mount Teide is Spain's tallest mountain.

When and how often Guanche populations island-hopped remains a mystery, but over time different groups of Guanches inhabited different islands. Living in isolation, they likely developed distinctive dialects and cultural traditions. At gatherings, neighboring tribes held wrestling matches from which the islands' traditional sport, called *lucha canaria* ("Canary fighting"), originated. The Guanches living on the western island of La Gomera, and likely those on Tenerife, used a set of distinctive whistles to communicate across the steep slopes. Writes Crosby: "Like Darwin's Galapagos finches, they were in all likelihood descendants from a few ancestors and had evolved independently on their separate islands. The Guanches would have provided anthropologists with a classic example of divergent cultural evolution if they, too, had survived."

Compared to the islands' plants, insects, and lizards, there is not a rich assemblage of mammals—at least not native ones—on the Canaries. Eight bat species inhabit the islands; one is endemic to the Canaries, while another occurs only on Macaronesian islands. A few shrew species live there, but these have questionable origins debated by scientists—are they recent introductions or truly endemic species? The Guanches hunted native wildlife, changed the landscape through agriculture, and introduced new mammals, including goats, pigs, dogs, and a rustic form of sheep. These new arrivals undoubtedly affected the native flora and fauna. Goats nibbled down native vegetation, as they do today. Pigs rototilled the underbrush, and dogs caught and ate large lizards, which also may have featured in the Guanche diet.

The largest living Canary Island lacerta, a now-rare herbivore called the Hierro giant lizard (*Gallotia simonyi*), grows up to two feet long. However, fossil remains indicate that far larger species roamed the islands when the first human inhabitants arrived. Some probably reached five feet long. Herpetologists believe that the relatively small size of today's Canary Island lizards may be the result of centuries of predation by invasive species and habitat deterioration brought on by domestic livestock. As the amount of vegetative cover dropped and introduced predator populations rose, lizards retreated to steeper habitats or smaller crevices and shrank in size. Pressure to evade predators must have increased centuries later, after cats and rats disembarked from European ships.

The Europeans: The Third Wave

The Romans and others knew of the Canaries for centuries, but European settlement of the islands didn't begin until the 14th century, when Italian explorer Lanzarote Malocello and his expedition arrived on his now-namesake island, Lanzarote. After living on the island for years, Lanzarote was killed by Guanches, who within a century would be killed off as well, replaced by Spaniards looking for new fortune. The islands were mapped a few years after Lanzarote's landing. Then, in 1402, French explorer Jean de Bethencourt and his comrades tried to conquer the Canary Islands, claiming that they wanted to convert the natives to Christianity. Bethencourt, soon funded by Castilian King Enrique III, had limited success, capturing a few islands and encouraging farmers from France to settle there. Bethencourt set the stage for Spanish possession of the islands, but it would take almost a century more to wrest all of the islands from the Guanches.

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COLOR FROM A CAGE

Bruce Coleman Inc./Hans Reinhard

A wild canary with dull plumage.

Bruce Coleman Inc./Hans Reinhard

Captive breeding has brightened canaries' feathers.

For most of us, the word canary brings to mind just one color—bright yellow. But the ancestors of today's fair songsters, which are native to the Canary, Madeira, and Azores islands, are anything but. In the wild, *Serinus canaria*, or island canaries, are a much drabber olive green or grayish-brown color than their caged brethren. In fact, the small, sweetly singing finches are difficult to spot because their coloring helps keep them hidden among the leaves.

The canary's color transformation is a tale of breeding that dates back to the 15th century, when Spaniards conquered the Canary Islands (which were named by Roman historian Pliny the Elder for the large wild dogs—or *canis* in Latin—that lived there, rather than for the native birds). Canaries were originally trapped and caged for their beautiful song, and there are two theories about how they made their way to Europe. One postulates that the Spanish invaders sent regular shipments of the birds back to the mainland, maintaining a monopoly on the market early on by selling only male birds. Eventually, however, females became available and captive canary breeding spread swiftly throughout Europe. The other theory is that in the early 16th century, a merchant ship traded with the Canary Islands and picked up a load of canaries, then wrecked off the island of Elba. A sailor released the caged creatures, but some were recaptured and sent to Italy as songbirds, and from there spread throughout Europe.

What the records do make clear is that by the 17th century canaries were being bred in Spain, Italy, France, Switzerland, and southern Germany. As the practice grew, breeding for qualities other than song—such as color and posture—also became popular, triggering the canary's change from dull green to what has become known as canary yellow. Like dogs, many breeds of canaries have been developed from their wild ancestors, and today these breeds are classified as song, type, or color canaries.

Wild canaries have four color pigments—two brown, one black, and one yellow. The brown and black pigments color the centers, edges, and undersides of the feathers. They are known as melanins and are formed from proteins produced by the birds' bodies. The yellow pigment, which forms a base of color on the feathers, comes from a fat-soluble material called lipochrome that is derived from the birds' diet, which includes grass seeds and weeds. The combination of the dark melanin pigments superimposed on the yellow lipochrome background gives wild canaries their green color.

However, the proportion of dark and light pigments in a bird's body is mostly determined by genes. One set of genes controls where the pigments will appear on the feathers, while another set determines which color will be displayed. Over the years, as breeding became a popular hobby in Europe and the canaries were bred with other songbirds, some of the genes controlling pigment patterns mutated, changing the way the melanins were displayed. The birds with mutated color genes were selectively bred; with each generation, less of the dark pigments showed, and more of the yellow background color was revealed. The end result is the canary yellow (and sometimes white, blue, red, or cinnamon) birds found in pet stores today.

—*Emily Hahn*

Bruce Coleman Inc./Bartomeu Borrell

Nigel Blake

Endemic euphorbia plants (*Euphorbia* spp.) grow on the volcanic terrain of Teno Rural Park in Tenerife (above); but the islands' native species are increasingly threatened by Barbary ground squirrels (*Atlantoxerus getulus*, below) and other invasives.

Meanwhile, strengthened by navigational advances, the navies of European nations were competing to acquire new lands and treasure, and the Canary Islands were often the first stop on the road to riches. There, ships could be docked, repaired, and provisioned with livestock and other supplies, plus enslaved Guanches.

Throughout the 1400s, Europeans brought new animals to the island chain, among them cattle, horses, domestic sheep, feral cats, European rabbits (*Oryctolagus cuniculus*), black (*Rattus rattus*) and brown rats (*R. norvegicus*), and house mice (*Mus domesticus*). By the late 1500s, the dry eastern islands were becoming barren after thousands of introduced donkeys and camels, along with the goats, chewed down much of the fragile vegetation. In 1591, more than 1,000 donkeys were slaughtered, for fear that they would totally denude the island.

Europeans also introduced many cultivated plants and weeds, which took hold and never left the islands. After it was introduced to the islands in the late 1400s, sugar cane became the Canaries' most important crop. Forests were felled to make way for cane fields and to fuel sugar mills. Sometimes the Canary Islands were a stepping-stone for new ways of doing things and invasive species to spread to other places. Slavery, farming and livestock-breeding, and settlement construction techniques were all field-tested in the Canaries before their exportation to the New World. At the end of the 15th century Columbus brought pigs and cattle from the Canaries to the West Indies, where they wrought their own damage on the New World's pristine ecosystems.

Europeans also introduced many cultivated plants and weeds, which took hold and never left the islands.

Mammal introductions, however, did not just occur centuries ago. They have continued. In 1965, for example, someone released a pair of chipmunk-like Barbary ground squirrels (*Atlantoxerus getulus*) on Fuerteventura. The crags and wastes of the island resemble the rodents' home range in nearby North Africa and provide what they need to survive. The ground squirrel is now the island's most visible non-farmyard, non-beach-going mammal. Individuals recently popped up on a few other islands, possibly carried over by people taking ferries from Fuerteventura.

In recent years, exotic birds also have flocked to the islands, thanks to transportation there by humans. According to the Spanish Ornithological Society, members of more than 100 bird species have escaped their cages or been intentionally released on the Canaries. A few established breeding populations of potential agricultural pest birds, most notably monk parakeets (*Myiopsitta monachus*) and ring-necked parakeets (*Psittacula krameri*), now nest throughout the island chain.

Tourism: The Fourth Invasion

These days, the Canary Islands provide Europe with bananas, tobacco, and a variety of other crops, but the biggest money-earner by far is the tourism industry, which draws about 10 million visitors to the islands each year.

Bruce Coleman Inc./Group Atlantide

A farmer tends a crop on Lanzarote, where agriculture has changed the landscape.

In the late 1960s, three decades after his rise to power, Spain's four-decade dictator Francisco Franco brought the Canaries fortune and fame by opening the islands to northern European visitors. The growth in the tourism business continues at a dizzying pace. Popular and cheap, the Canary Islands have become a bit of a cliché to Europeans, like Daytona Beach, Florida, became for vacationing Americans. But their appeal still shines through. "At four hours from London, there aren't many other options in comparison," said a travel guide publisher interviewed in *The Times* (London) in October 2004.

Some islands, such as La Gomera and El Hierro, remain less developed and have protected areas that embrace much of their exceptional biodiversity. On the popular tourist islands, though, shoreline development is intense and spreading inland. Canary Islands government officials now work with tourism and environmental groups to protect wild areas, and have entertained thoughts of curbing development on some islands. But proposals often bog down before becoming legislation, and the tourism industry continues to boom. Over the past few decades on

Nigel Blake

An endemic houbara bustard on Fuerteventura, where resort development is encroaching on wildlife habitat. Male houbaras put on a dramatic courtship display, flaunting white plumes of feathers on their crests, heads, and chests for female onlookers.

Fuerteventura alone, the resident population has risen to 73,000 from 15,000. Meanwhile, each year 1.3 million tourists descend upon this island for short visits.

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A few months after my Tenerife visit, I stood about 130 miles to the east, on the rain-starved eastern island of Fuerteventura. Lower and closer to Africa, Fuerteventura—which sits 60 miles from Morocco—rarely captures the trade-wind moisture that shrouds the mountainous western outliers. In a semi-desert setting as extreme as I could get from Tenerife's *laurisilva*, I watched a gray-and-brown turkey-sized bird called the houbara bustard (*Chlamydotis undulata fuertaventurae*) scuttle in zittery figure-eights amid a field of boulders, his head hidden in puffy white plumes as he advertised his virility.

After the bird strutted behind a boulder and disappeared, I drove 15 miles back to the coastal resort town of Corralejo, convinced that I'd seen one of the most bizarre courtship rituals in the animal world. As I drove, I also worried about the bird's future. Within two miles of the bustard's stony field, I passed freshly bulldozed earth, the first mark of extensive resort development that now stretches the remaining 13 miles to the Atlantic.

I later read that much of the houbara bustard habitat in the north of the island lies just outside of protected areas. As best I could tell from maps, the parading bustard—a member of an endemic island subspecies—had set up his display run just beyond the border of a natural park. With perhaps 500 individual birds divided between Fuerteventura and nearby Lanzarote, would this legally protected bird bow to the bulldozers and follow the path of the Canary Islands oystercatcher (*Haematopus meadewaldoi*)? The oystercatcher, a large shorebird that once nested on these islands, had gone extinct by 1940, probably due to competition with people for its mollusk prey, disturbance on its nesting grounds, and relentless attack from introduced cats and rats that preyed upon it and its eggs.

The Canary Island ark is shaky at best, but it has fared better than those of many other biologically diverse island groups. The scientific and conservation communities, as well as government officials and tourism industry groups, all recognize the need to preserve the islands' natural assets. This combined will needs to rise to the next level, resulting in firm action that protects what is left, especially in areas not currently protected as reserves. As the fourth invasion continues, hope remains that as both a European playground and a treasure trove of biodiversity, the Canary Islands will some day soon reach an equilibrium that accommodates the whims of humanity while preserving the archipelago's distinctive collection of wildlife castaways. Z

—Contributing editor Howard Youth wrote this article while living in Madrid, Spain. He has since moved back to the D.C. area.

Books, Naturally

The Ancestor's Tale: A Pilgrimage to the Dawn of Evolution

Richard Dawkins. 2004. Houghton Mifflin Company, Boston and New York. 673 pp., hardbound. $28.

The Ancestor's Tale has all the makings of a "trophy book." Written by renowned evolutionary biologist Richard Dawkins, who bears the lofty title of Charles Simonyi Professor of the Public Understanding of Science at Oxford University, it is a must-buy for people aspiring to be—and appearing to be—intellectually au courant. However, at 673 pages, it is likely to be guiltily shelved, unread, after an appropriately long stint on the coffee table. "After all," people are wont to think about a book such as this, "I'm busy, and I did read all the reviews."

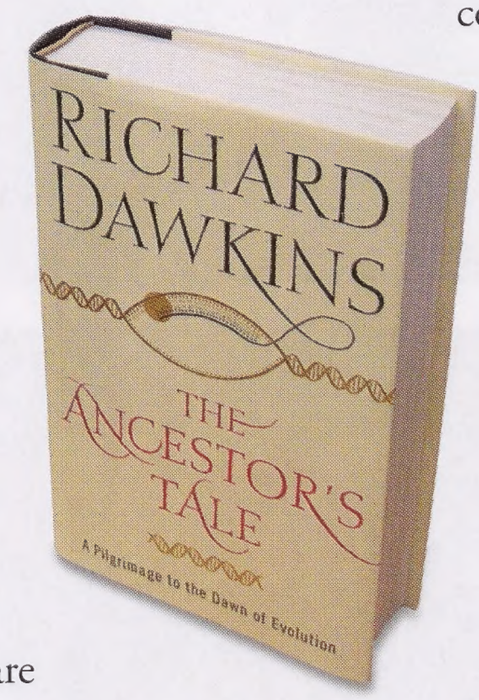
I admit to having more than my fair share of trophy books, and I assume that, like me, many *ZooGoer* readers quail at the prospects of ever finding time to read so many pages. So I started reading *The Ancestor's Tale* expecting not even to come close to finishing it, much less reviewing it here. As a rule, I choose books to review only if I think you can read them with pleasure, and learn some interesting biology, in the course of a few Metro commutes or between chores on a couple of weekend afternoons.

If ever there has been an excuse for breaking this rule, *The Ancestor's Tale* is it. Let me encourage you, no, urge you, to scrape time from your hectic schedule, gather up your intellectual courage, and take an amazing adventure through the four-billion-year-long history of life on Earth with the smartest, funniest, most exuberant tour guide one can imagine.

Taken all together, *The Ancestor's Tale* is sort of an uber-lecture on evolution delivered by an equally uber professor who, by dint of his erudition, his passion for the subject, and his irrepressible desire to share both, holds his class in thrall until, long—very long—after the bell has rung, his amazed students have learned seemingly all there is to know about what we know about the history of life on Earth.

Traveling backward in time, Dawkins invites readers to meet our ever-more distant ancestors at 40 rendezvous—points in time when our most recent ancestors joined up with their most recent ancestors until all converge on a single ancestor from which all of surviving life evolved. (Thus, Rendezvous 1, some five to seven million years ago, is when humans shared a common ancestor with chimpanzees. Rendezvous 2 marks the common ancestor of both humans and chimpanzees on the one hand, and gorillas on the other, and so on until Rendezvous 39 when the common ancestor of humans, invertebrates, fungi, plants, and others, was a bacterium.)

At each rendezvous, and other rest stops along the road, Dawkins stops to tell fascinating tales about particular species that illuminate some principle of evolutionary biology—from the first, "The Farmer's Tale" that discusses domestication, to the penultimate, "The Rhizobium's Tale," which takes on the creationist theory of "intelligent design" with a story of the only creatures to have evolved a true wheel for locomotion, to the last, "The Taq's Tale," with its surprising conclusion that we humans are "more similar to some bacteria than some bacteria are to other bacteria."



Dawkins writes with great clarity and wit, most evident when at his opinionated best he skewers the ideas of those he disagrees with. I can't help quoting my favorite such passage at length: "Creationists love the Cambrian Explosion [a time from which huge numbers of fossils of very diverse forms occur compared to before] because it seems, to their carefully impoverished imaginations, to conjure a sort of paleontological orphanage inhabited by parentless phyla: animals without antecedents, as if they had suddenly materialized overnight from nothing, complete with holes in their socks. At the other extreme, romantically overheated zoologists love the Cambrian Explosion for its aura of Arcadian Dreamtime, a zoological age of innocence in which life danced to a frenzied and radically different evolutionary tempo: a prelapsarian bacchanalia of leaping improvisation before a fall into the earnest utilitarianism that has prevailed since." More succinctly, referring to one theory about this same explosion, he writes, "This third school of thought is, in my opinion, bonkers."

I don't want to mislead you: This book is not always an easy read. It is replete with arcane terminology and covers some very complex concepts. (Before launching into "The Gibbon's Tale," Dawkins warns, "Readers should either don their thinking caps for the next twelve pages, or skip now to page 137. . ."). But don't let this deter you—there will not be a test. Just skip along and read the good parts, many of which you won't be able to resist reciting to whomever will listen. Don't worry about understanding, far less remembering, all of "the extravaganza of details." Rather, let *The Ancestor's Tale* amaze and delight you with the fact that, thanks to evolution, "there are any such details to be had at all, on any planet." Hit the road, take the pilgrimage.

—*Susan Lumpkin*

BioAlmanac

by Emily Huhn

Revolutionary Evolution

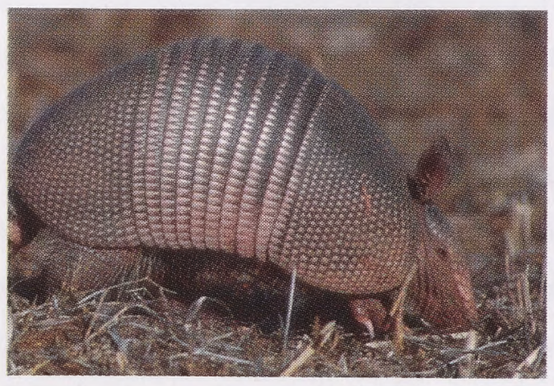
Poisonous cane toads first hopped onto Australian soil in 1935, wreaking havoc on native creatures in Queensland. For many snakes, eating one of these toxic toads is fatal, but some are adapting with what scientists call "contemporary evolution."

Scientists from the University of Sydney studied the long-term effects of the cane toad (*Bufo marinus*) invasion on snakes. They began by examining 623 preserved snake specimens from the Queensland Museum collected over the last century. The scientists knew that the size of a snake's prey is limited by the size of the snake's head. Therefore, snakes with smaller heads relative to their body size are less likely to eat toads big enough to kill them. The scientists suspected that these snakes were more likely to survive and pass on their genes.

The study, published in December 2004 in the *Proceedings of the National Academy of Sciences*, suggests that this is indeed the case. The two species in the study that are most vulnerable to the toads—the red-bellied black snake (*Pseudechis porphyriacus*) and the green tree snake (*Dendrelaphis punctulatus*)—seem to be evolving smaller heads and longer bodies. The authors speculate that organisms can also evolve rapidly in response to natural events, global warming, and pollution.

What's in a Name?

The word "armadillo" is Spanish in origin, and it means "little armored one." The nine-banded armadillo is the only armadillo native to the United States; it also lives in South and Central America. The Aztecs called it *azotochtli*, meaning "tortoise-rabbit," presumably because it has a carapace of hard plates on its back and head that resemble a tortoise shell, and rabbit-like ears. Linnaeus later named its genus *Dasypus*—"rabbit" in Greek—and its species *novemcinctus*, which means "nine bands" in Latin. Strangely named armadillos include the screaming hairy armadillo (*Chaetophractus vellerosus*), which squeals when threatened, and the pink fairy armadillo (*Chlamyphorus truncatus*), the smallest armadillo and bearer of a pale pink shell.



Armadillos, sloths, and anteaters once belonged to the order Edentata, which means "toothless" in Latin. Although all modern members of this order lack incisors and canines, the designation was a misnomer—only anteaters have no teeth. In fact, the giant armadillo (*Priodontes maximus*) can have as many as 100. The order was renamed Xenarthra, meaning "strange joint" in Greek, to describe these animals' unusual vertebrae.

According to ancient Mayan myth, the sun god Hachakyum created armadillos to exact revenge. He persuaded two lesser gods who had angered him to sit on a bench, then changed the bench into a pair of armadillos that leapt into the air, knocking the gods to the ground and humiliating them.

Do Bees and Wasps Die After Stinging?

Bees do, but wasps don't. Bees generally sting only to defend their hives. Their barbed stingers, attached to venom sacs and poison glands, remain stuck in the victim. To disengage themselves after stinging, bees must tear their abdomens from their spent stingers; consequently, they die within two days. In contrast, the stingers of wasps, yellowjackets, and hornets do not have barbs, and are used repeatedly to paralyze or kill prey. Only females can sting, because the stinger is actually a modified ovipositor, or egg-laying tube.

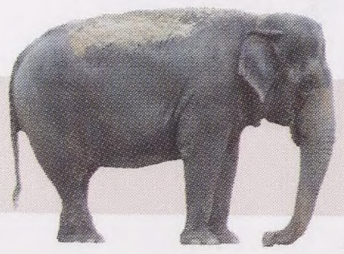
Fact or Fiction: Ostriches Bury Their Heads in Sand

It is a common misconception that ostriches (*Struthio camelus*) bury their heads in the sand when they are in danger. When provoked, these large flightless birds can sprint up to 50 miles per hour with a stride reaching up to 15 feet. They can also kick with a force of up to 500 pounds per square inch. But, when an ostrich cannot run away, such as when it is incubating eggs, it will stretch its long neck and head out on the sand and remain still. The light color of the head and neck help it blend in with the ground. From a distance, only the ostrich's bush-shaped body is visible, so it looks like the head is buried.

In Season

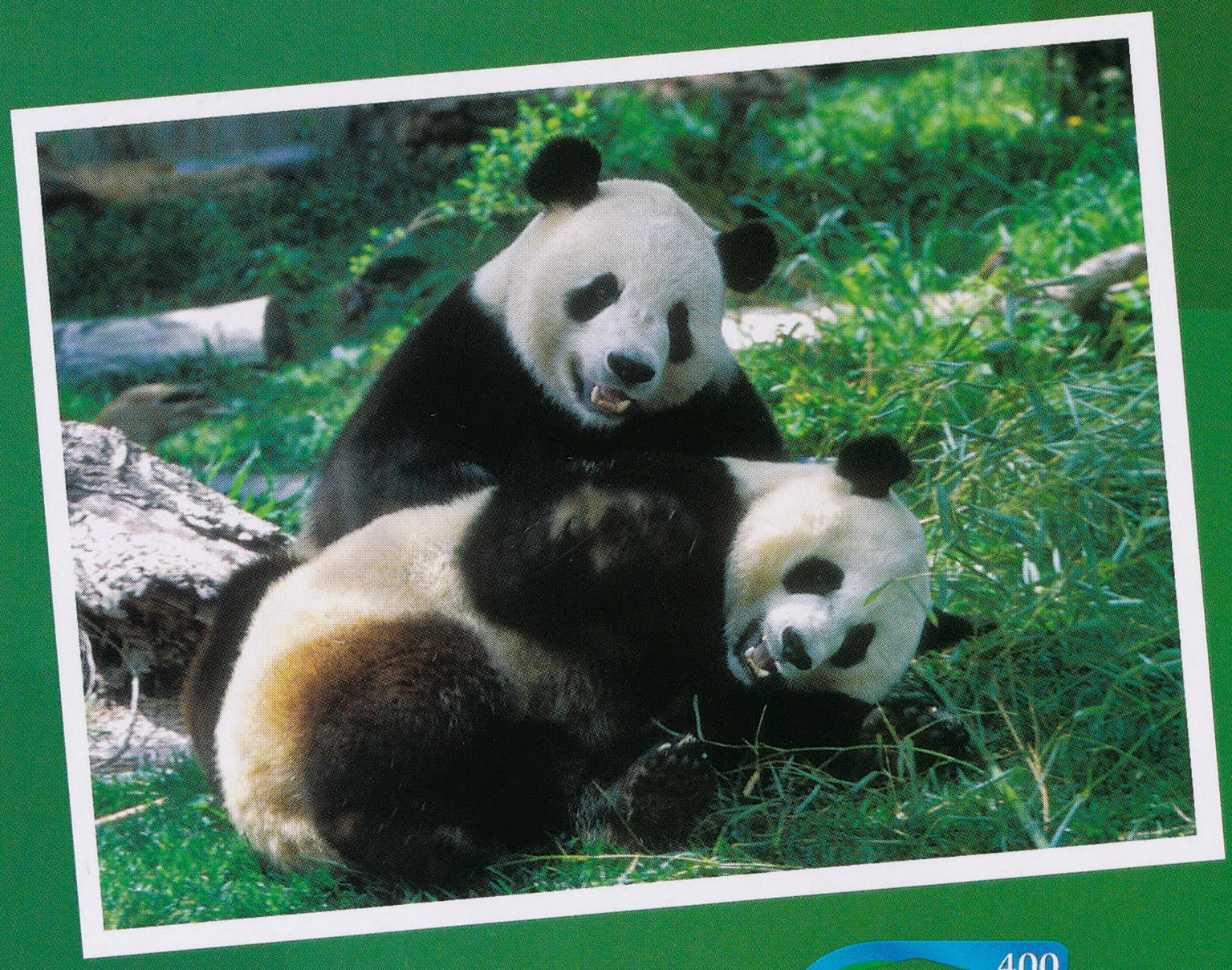
With the arrival of spring, mother Virginia opossums (*Didelphis virginiana*) become jungle gyms for their young. When *D. virginiana* offspring are about 70 days old, they outgrow their mother's marsupial pouch, scramble through her fur, and climb onto her back for a ride. There may be as many as 20 baby opossums per litter at birth, and they are so small that it would take more than 200 of them to weigh one ounce. The babies crawl from the birth canal into the pouch, which has 13 mammae. Only those opossums that latch onto a nipple have a chance to survive.

Snake (*Pseudechis porphyriacus*): Steve Wilson; bee: Jack Dykinga/ARS; armadillo: J. & K. Hollingsworth/USFWS; elephant: Jessie Cohen/NZP



The gestation periods of African (*Loxodonta africana*) and Asian elephants (*Elephas maximus*) are the longest of any mammal; they last about 630 to 660 days, or 20 to 22 months.

Fujifilm, preserving more than just memories.



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Partners in Conservation Education

Among the best recognized, but rarest animals in the world, giant pandas have come to symbolize endangered species and international conservation efforts. In an effort to help protect the giant pandas and secure their future, Fujifilm is proud to be the lead corporate sponsor of the Zoo's giant panda program.

Fujifilm's support helped the National Zoo bring giant pandas Mei Xiang and Tian Tian to Washington, and is assisting the Zoo's experts to develop the scientific knowledge they need to ensure the survival of pandas in the wild. Fujifilm also supports comprehensive conservation education programs designed to help children and adults learn more about giant pandas and the conservation of all wildlife and their habitats.

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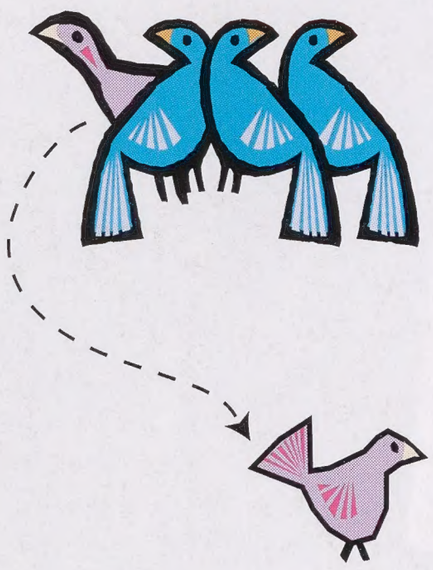
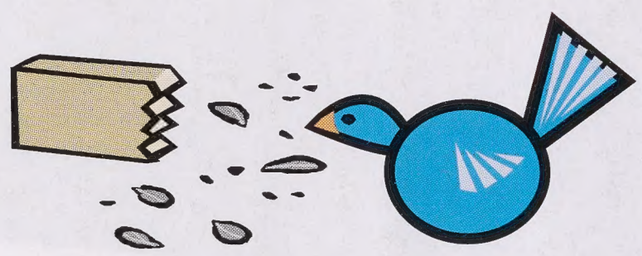
Get the Picture

With gourmet fare from Washington's finest restaurants, wines from dozens of vintners, live entertainment, and only three hours to do it all, follow these tips for a fabulous time at ZooFari.



1. Fly by the slow-movers



2. Eat as much as you can

3. Shake your tail feathers and make room for more

FONZ Friends of the National Zoo

National ZooFari 2005: Wing Ding

Tickets are on sale now at www.fonz.org.

FONZ Friends of the National Zoo

Friends of the National Zoo, 3001 Connecticut Avenue, NW, Washington, D.C. 20008, **www.fonz.org**